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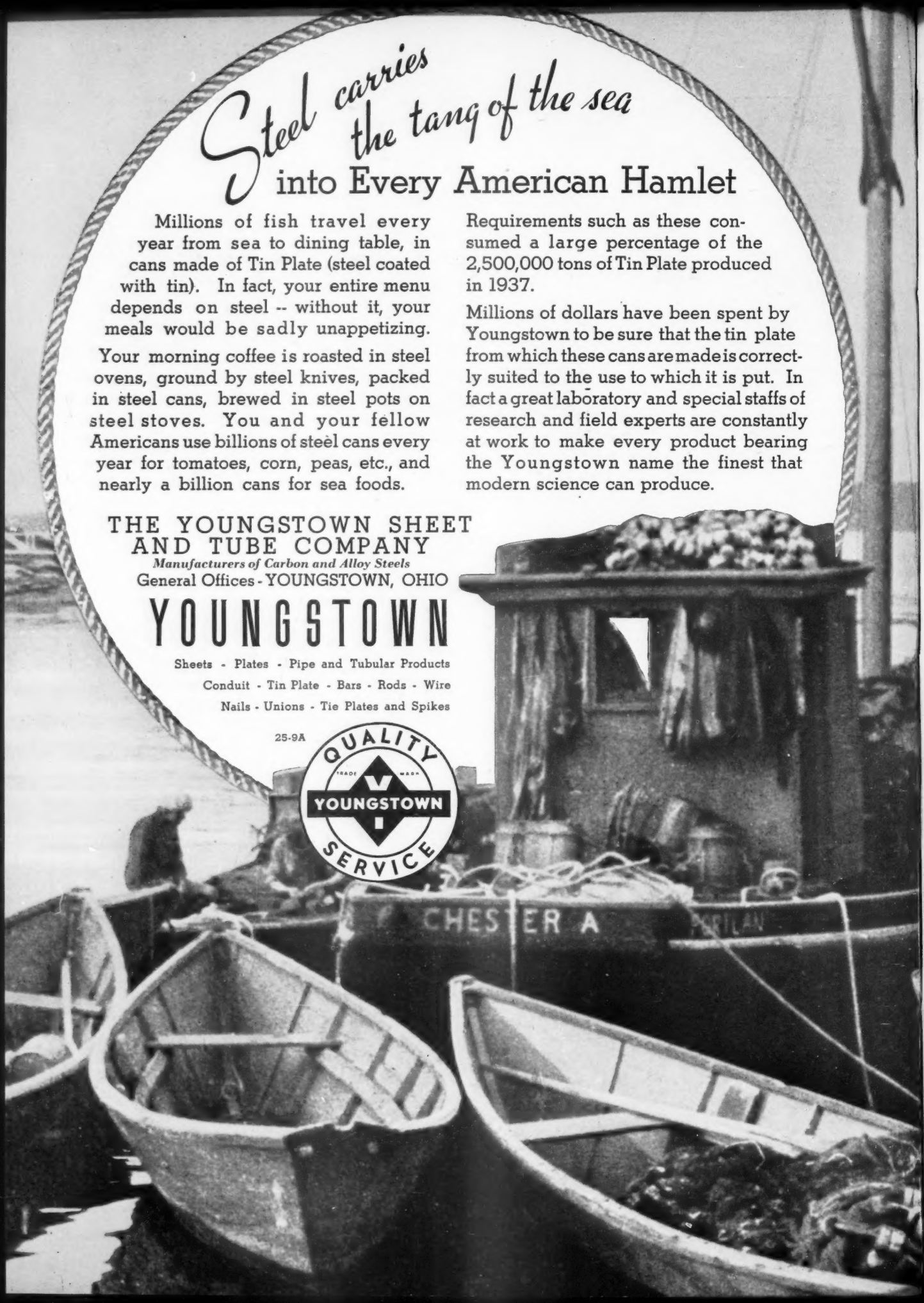
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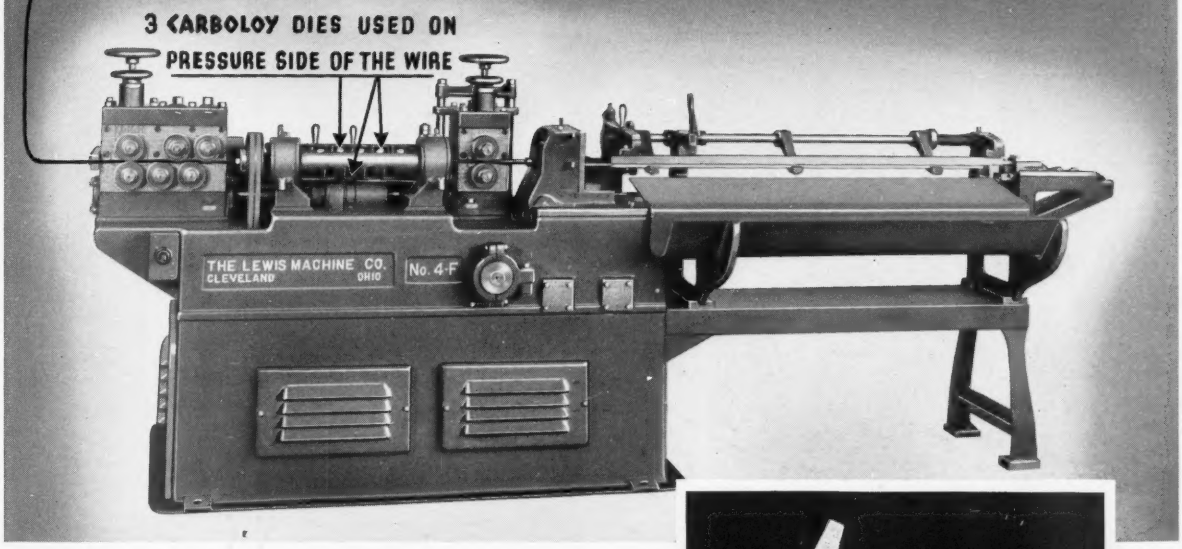

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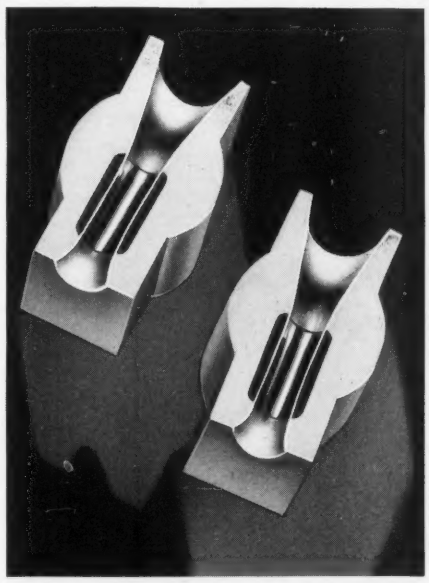

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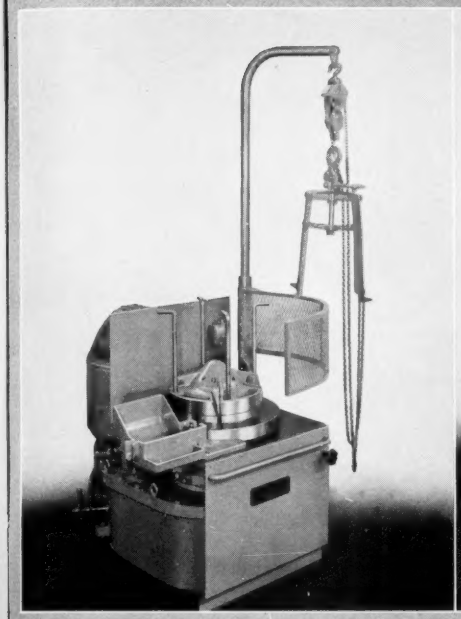

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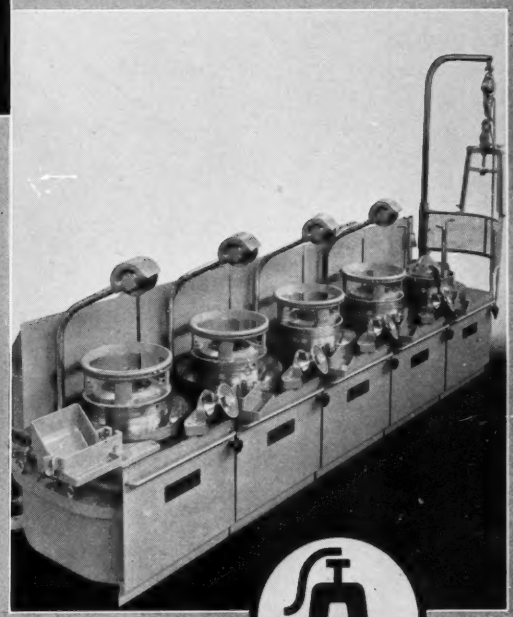

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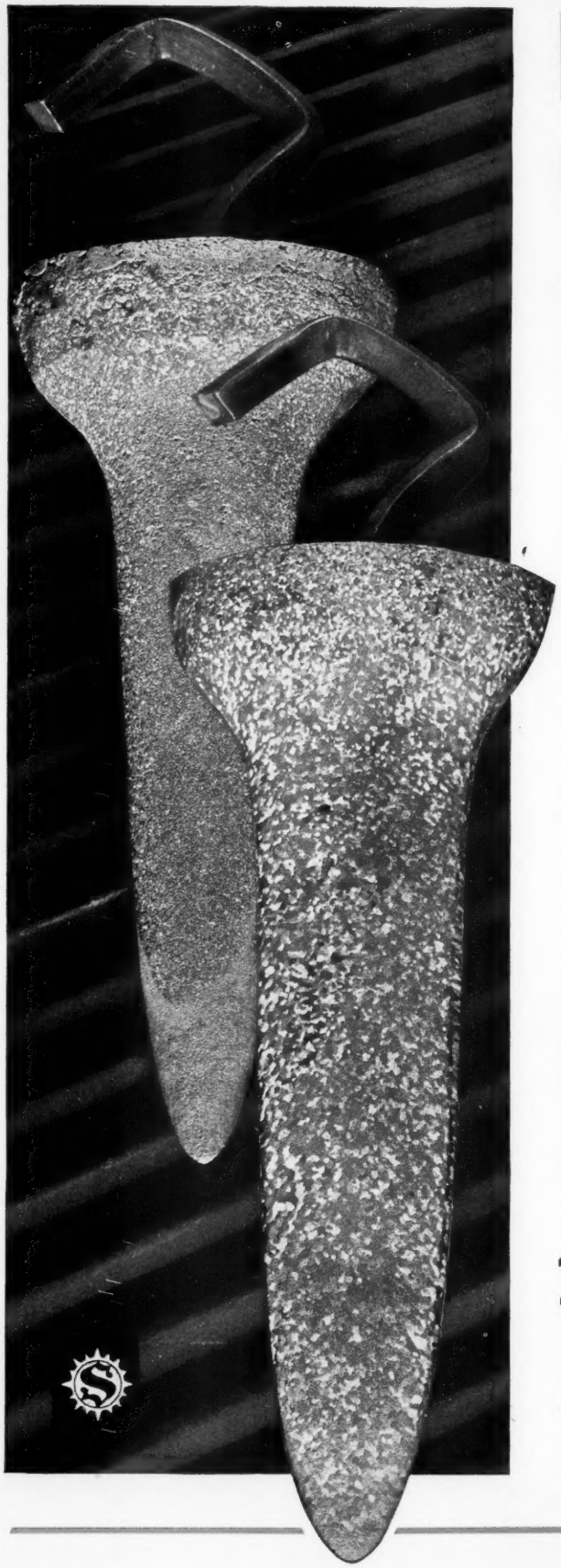

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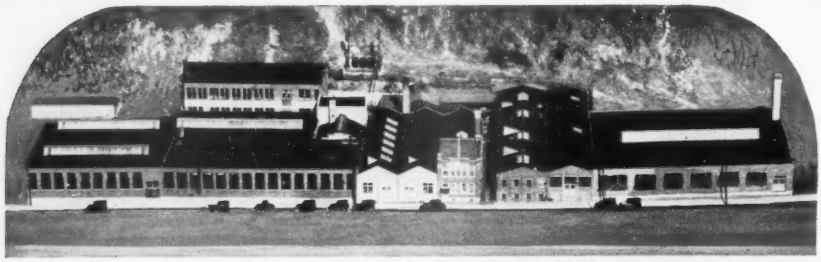

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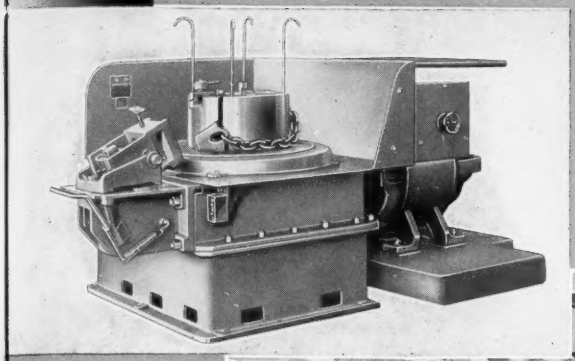

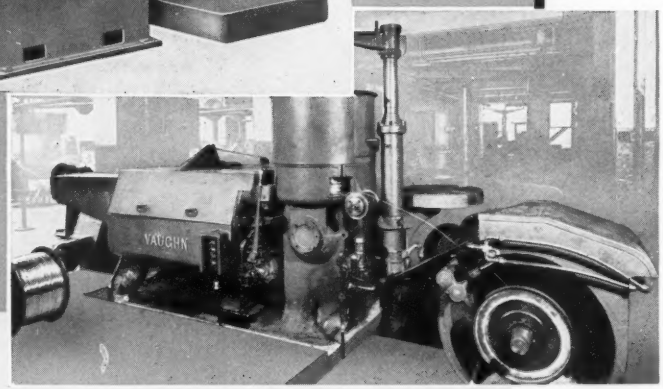

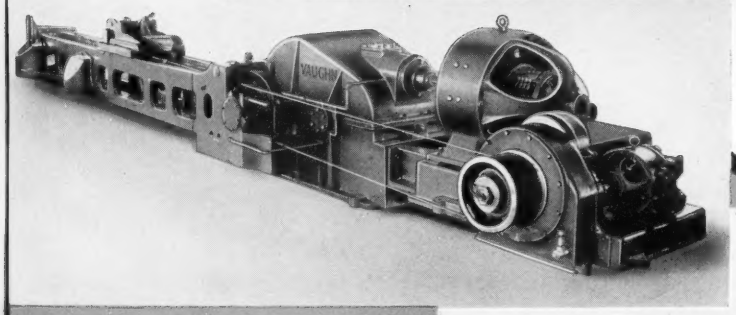

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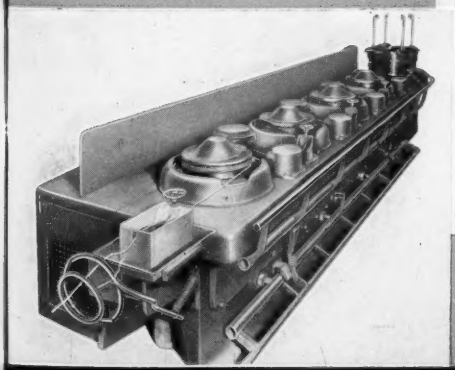

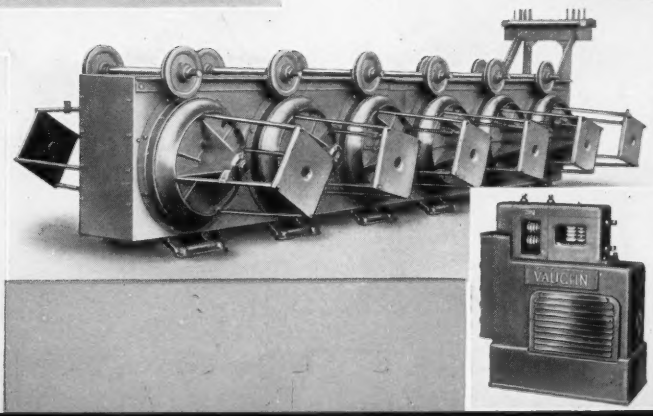

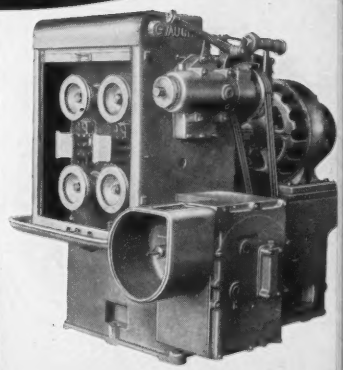

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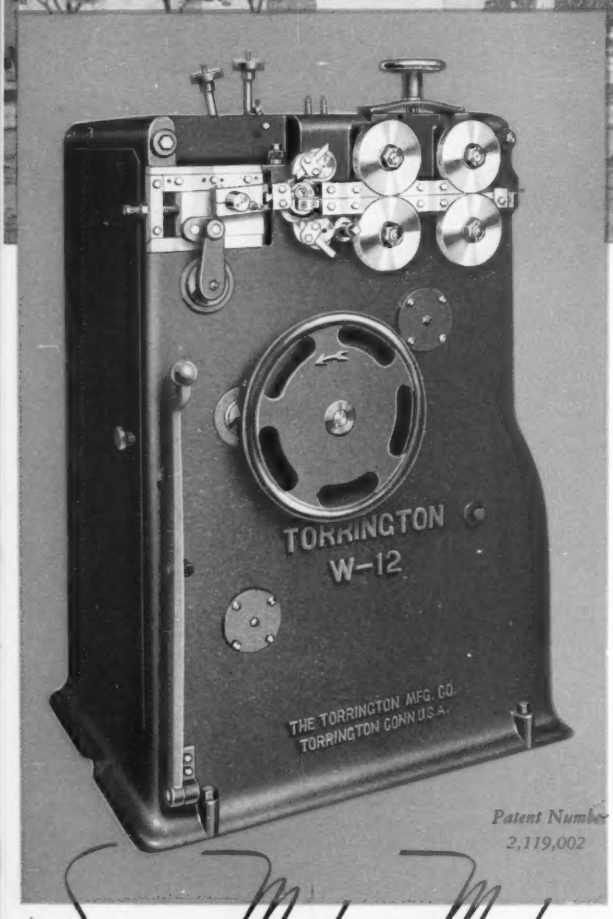

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WIRE AND WIRE PRODUCTS

A monthly publication devoted to the production of Wire, Rod and Strip, Wire and Rod Products and Insulated Wire and Cable

DRAWING—ROLLING—EXTRUDING—FORMING—FABRICATING

Vol. 13 DECEMBER, 1938 No. 12

Designated as

Official Publication By The Wire Association

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ANNOUNCEMENT

of the

SPECIAL ISSUE

for

JANUARY 1939

SPECIAL BECAUSE:

The discussions on technical papers at the annual meeting of the WIRE ASSOCIATION will be published in their entirety in the regular January issue of WIRE and WIRE PRODUCTS.

✦ ✦ ✦

The directors of the WIRE ASSOCIATION have approved this plan to provide these discussions to all subscribers without extra expenditure.

✦ ✦ ✦

TO OUR ADVERTISERS:

The advertising value of this special arrangement to be followed in the January issue of WIRE and WIRE PRODUCTS is obvious.

✦ ✦ ✦

Standard rate card will apply to this issue.

✦ ✦ ✦

Closing date
December 15th, 1938

✦ ✦ ✦

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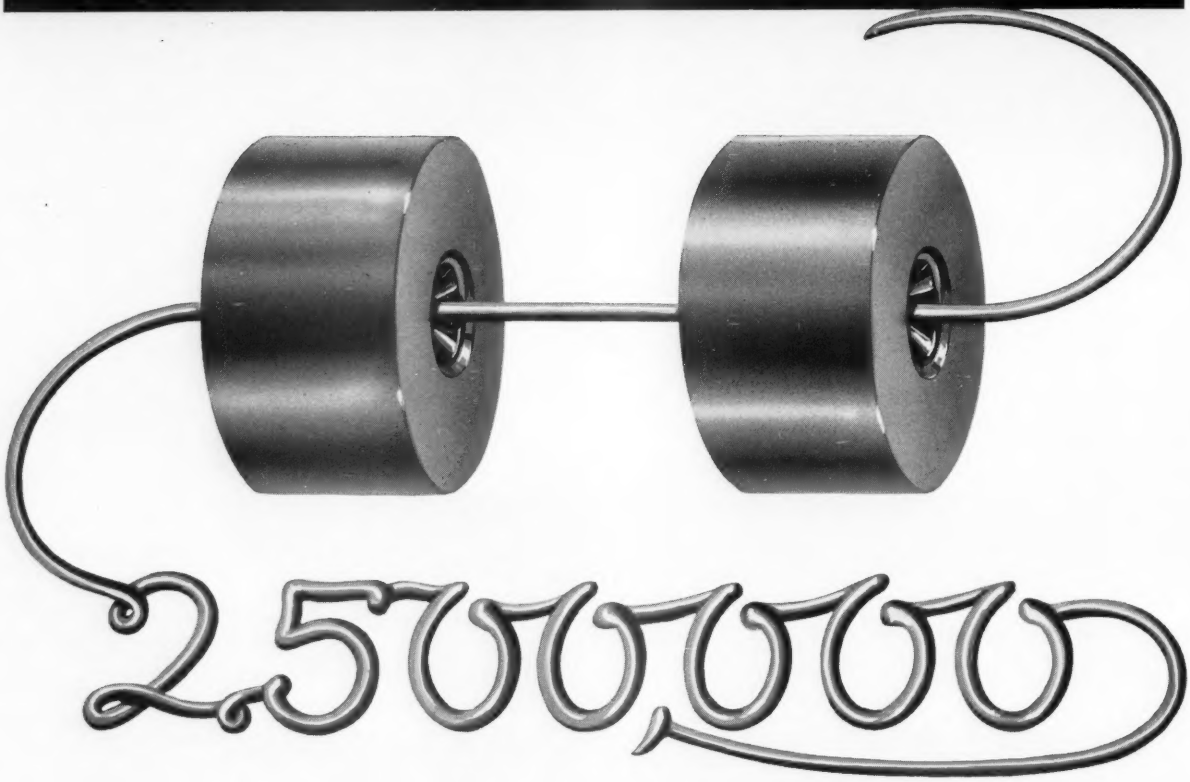

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A monthly publication devoted to the production of Wire, Rod and Strip.
Wire Products and Insulated Wire and Cable.
DRAWING --- ROLLING--- EXTRUDING --- FORMING --- FABRICATING

Vol. 13 DECEMBER, 1938 No. 12

Fundamental Principles of Steel Wire Metallurgy

PART II — THERMAL REACTIONS

By B. L. McCarthy,

Chief Metallurgist, Wickwire Spencer Steel Company,
Buffalo, N. Y.

FOREWORD

This is the second of a series of three lectures delivered before the Wire Association October, 1938.

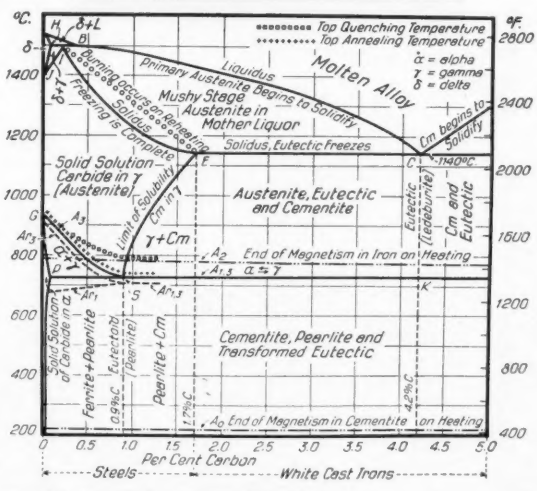
In these lectures the author has attempted to present the fundamental principles of steel wire metallurgy in a manner which will make it understandable to the layman. The third lecture will be published in the January, 1939 issue of Wire & Wire Products. ✦ ✦ ✦ ✦ ✦

Iron-Carbon Equilibrium Diagram

IN the same manner as the data for the construction of the M_1-M_2 Equilibrium Diagram, shown in Part I, were developed, so also has the Iron-Carbon System been studied. Because of the importance of this system of alloys, instead of just the lines showing the melting points of various Iron - Carbon combinations, numerous curves showing the variety of reactions have been plotted.

✦ ✦ ✦

THE Complete Iron-Carbon Diagram embracing all the changes which take place when Iron and Carbon combinations are heated and cooled, is shown in figure H. This diagram covers the range from Cast Iron, high in carbon, down to the lowest carbon material. To make a complete study of it would not fall within the intended scope of these lectures, we are however, interested in the portion which pertains to changes that take place in the solid state. This is the portion, which embraces the heat treatment of steel and is indicated by the lines GS, SE, PSK and GPN. In the solid state, the changes are those of solution and precipitation of ferrite and iron-carbide and the term Iron-Iron Carbide Diagram is often employed to designate that part of the complete diagram, which is shown enlarged, in figure 1.



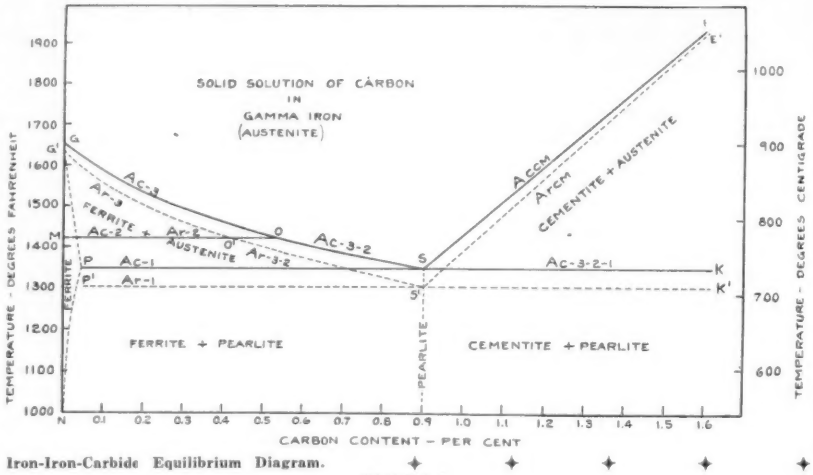
Complete Iron-Carbon Equilibrium Diagram.
FIGURE H

THE point S which corresponds to approximately .9% carbon is the composition of lowest solid solubility of Iron and Iron-Carbide and is termed the Eutectoid Composition. The temperature of 1330° F. is the lowest temperature at which, on slow cooling, iron-carbide and ferrite are soluble in each

other. Below this point a definite transformation takes place and carbon in the form of Iron-Carbide precipitates out, forming the alternate plates of cementite and ferrite, identified under the microscope as the lamellar structure of pearlite.

✦ ✦ ✦

THE word **Eutectoid** is employed to distinguish the lowest point of solid solubility from the lowest melting point termed Eutectic; see point C in figure H. Pearlite, the eutectoid structure, is composed of 13% cementite, (containing 6.6% carbon and 93.4% iron) and 87% ferrite. If the composition of the metal is other than .9% carbon, the structure of pearlite will be formed on slow cooling but there will be present, in the metal, an excessive amount of ferrite or cementite. This ferrite or cementite, as the case may be, which is present in the metal in excess of the amount required to make up the 13% cementite and 87% ferrite of the pearlite is termed **Free Ferrite** or **Free Cementite** to distinguish it from the ferrite and cementite combined to form Pearlite. If the carbon content of the steel is below .9%, we have free ferrite present as the excess constituent and is termed a **Hypo-Eutectoid Steel**. If the carbon content is above .9% the excess constituent is free cementite and it is termed a **Hyper-Eutectoid Steel**.



Iron-Iron-Carbide Equilibrium Diagram.

FIGURE I

✦ ✦ ✦

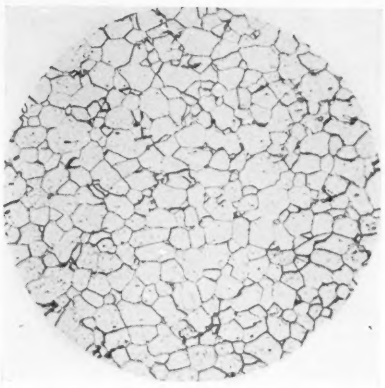
ABOVE the lines GS and SE we have total solubility of carbon in iron at whatever percentage is present in the sample, from .01 to 1.7 carbon. This is the solid solution metallographically termed **Austenite,** and even though the temperature is high, the fact that it is solid means it is crystalline. In figure 13 is shown the structure of Austenite. This structure resembles that of a pure metal, because, like pure metals, there are no precipitated constituents. In plain carbon steels it is impossible to retain Austenite at room temperatures but by the addition of alloys such as Chromium and Nickel in large percentages, the temperature at which the line PSK occurs may be lowered to a point where Austenite can persist at atmospheric temperature. The photomicrograph shown in figure 13 was taken from a sample of Stainless Steel containing 18% Chromium and 8% Nickel.

✦ ✦ ✦

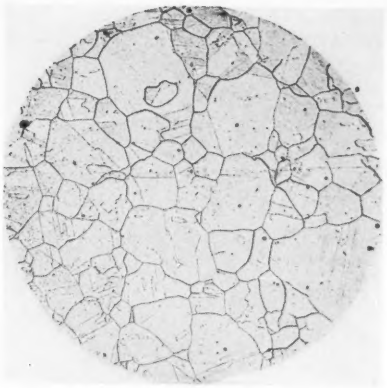
THE line GS represents the solubility of ferrite, and serves to indicate the amount of free ferrite in solution in the Austenite for various compositions. As the carbon content is decreased from that of the Eutectoid composition, the amount of ferrite is increased and a higher temperature is required for its solubility. If, for example, we have a .5 carbon steel, free ferrite will begin to precipitate as soon as the temperature is lowered to the point in the line GS corresponding to .5 carbon, this is approximately 1450°F. On further lowering of the temperature, ferrite will continue to precipitate out. This precipitation of ferrite raises the Carbon content of the remaining Austenite until finally, at the line PSK, all the Free Ferrite has precipitated and we have the Eutectoid Composition in the remaining Austenite. At this point, the Austenite transforms and we have the structure of Pearlite. The line PSK is sometimes referred to as the lower critical point and the line GSE as the upper critical point, the space between these lines is referred to as the critical range. This applies whether the steel is being heated or cooled. In Hypo-Eutectoid steels we will have free Ferrite and Pearlite, the amount of each varying with the carbon content of the steel. In the case of Hyper-Eutectoid steels, the same general condition prevails, except that in this case cementite is the excess constituent. For a given carbon content, in excess of the Eutectoid composition, Iron-Carbide will precipitate out of the solid solution of Austenite as the line SE is passed and by so doing, lower the Carbon content of the remaining solid solution. This precipitation continues as in the case of ferrite in Hypo-Eutectoid steels until the line PSK is reached at which time the Austenite transforms to Pearlite and the structure will consist of Pearlite and Cementite.

✦ ✦ ✦

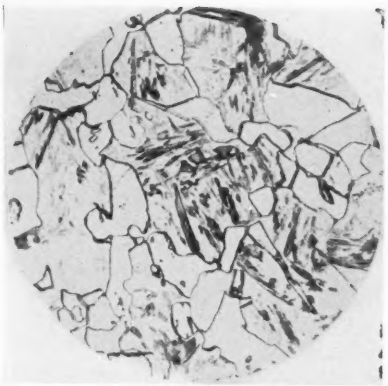
ABOVE the line GSE we have the face-centered cubic space lattice of Gamma Iron. Between the lines GS and PSK also SE and PSK the precipitated material will be of the body centered variety called Alpha Iron, mixed with the face-centered Gamma Iron of the remaining Austenite. Below PSK only the body-centered cubic space lattice of Alpha Iron prevails. Iron is also present in the form of **Delta Iron** and **Beta Iron,** both of these however, have the same crystallographic form as Alpha Iron, namely body-centered cubic space lat-



Structure of Austenite. Magnification 100X. ✦
FIGURE 13



Martensite and Ferrite Produced by Quick Cooling from 1350°F. Magnification 1000X. ✦
FIGURE 14



.05 Carbon Steel Showing Absence of Pearlite, Compare with Figure 18. Magnification 200X.
FIGURE 15

tice. They represent allotropic changes which are indicated in the time-temperature curve employed in the construction of the Iron-Carbon Diagram, but have no significance in our present study.

✦ ✦ ✦

TO demonstrate the presence of both ferrite and austenite in the range between the lines GS and PSK, a sample of .4% carbon steel was heated to 1700°F for ten minutes to insure complete solution of the constituents, then transferred immediately to a lead bath maintained at 1350°F.

✦ ✦ ✦

THIS treatment permitted the precipitation of the excess ferrite but because the temperature was too high for transformation the carbon was still in solution. The sample was then quenched from the lead bath in water. A thin section (.125") was employed and the sudden quench prevented further precipitation of ferrite and the cementite. This resulted in the development of the structure termed Martensite which consists of a solid solution of Iron-Carbide in Alpha Iron, this constituent will be discussed at length later.

✦ ✦ ✦

IN figure 14 is shown a photomicrograph of the structure produced by this treatment. The white areas are the ferrite while the needle-like structure is the martensite. These areas (martensite), are the areas which were austenitic at 1350°F.

MARTENSITE is a direct product of austenite, produced on sudden cooling. The fact that it is present in this structure is proof of the existence of both ferrite and austenite between the lines GS and PSK and that both Alpha and Gamma Iron are present in this range.

✦ ✦ ✦

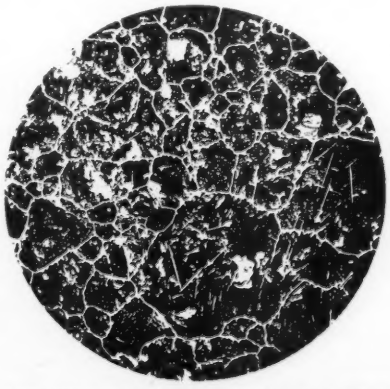
THE line MO (Fig. 1) is an example of a point where a change takes place, the nature of which is not clear. The fact that steel loses its **Magnetism** on heating to the temperature indicated by it, is evidence that some change takes place. This is not important in connection with this study however.

✦ ✦ ✦

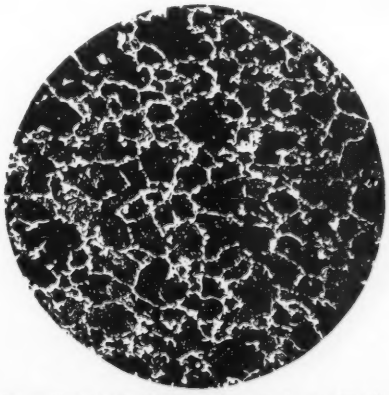
THE line GPN as shown in the Iron - Iron Carbide diagram represents the solubility of cementite in Alpha Iron.

AS previously stated, Iron Carbide is soluble in Gamma Iron but insoluble in Alpha Iron, below the line PSK however, there is a small amount, equivalent to approximately .05% carbon, which is soluble to a limited extent in Alpha Iron as shown by this line. This degree of solubility reaches its maximum at approximately the temperature corresponding to the line PSK and then precipitates as the temperature is lowered, until at room temperature precipitation is complete. This means that a small amount of carbon will not form pearlite at the PSK temperature on slow cooling, but will remain in solution and the subsequent precipitation of cementite will be in the form of rounded particles rather than the plate-like structure. In figure 15 is shown a .05 carbon steel, note the absence of the dark areas of Pearlite shown in figure 18.

✦ ✦ ✦



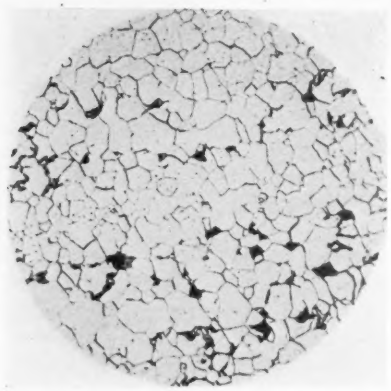
Hypo-Eutectoid Steel (.65 Carbon) Slowly Cooled from 1700°F. Note the network of Free Ferrite. Magnification 200X. ✦ ✦ ✦
FIGURE 16



Hyper-Eutectoid Steel (1.35 Carbon) Slowly Cooled from 1700°F. Note the Free Cementite Network. Magnification 200X. ✦ ✦
FIGURE 17

Austenitic Grains

WHEN steel is cooled from above the line GSE, the precipitation of the excess constituent which takes place, is from the center of the Austenitic grains and proceeds by the diffusion of ferrite or cementite to the grain boundaries. In this manner a network of free ferrite or free cementite is formed around the Austenitic grains, which serve as markings to indicate the grain size which existed above GSE. In figure 16 is shown a .65 carbon steel slowly cooled from above 1700°F. Note



.10 Carbon Steel Showing Pearlite (Dark Areas) and Alpha or Actual Grains of Ferrite (White). Magnification 200X.

FIGURE 18

the free ferrite network. In figure 17 is shown a steel containing 1.35 carbon slowly cooled from above the line SE; in this case the network consists of free cementite.

✦ ✦ ✦

INASMUCH as the precipitation of free ferrite or free cementite takes place before the line PSK is reached and prior to the development of the Eutectoid Composition in the Austenite it is often referred to as **Pro-Euctectoid Ferrite** or **Pro-Eutectoid Cementite.**

✦ ✦ ✦

AS the carbon content of the steel is lowered the amount of ferrite present is far in excess of that required to furnish boundary markings, and appears in the structure as a matrix surrounding small islands of Pearlite, the size and number of which varies with the carbon content. In figure 18 is shown a .10 carbon steel. Note the occasional dark areas, these are the pearlitic island; the white is ferrite.

✦ ✦ ✦

Actual or Alpha Grains

AS previously stated, above the line GSE we have a definite grain structure of Austenite—see figure 13. On cooling the transformation from Gamma to Alpha Iron results in a complete re-arrangement of the atoms and a new set of grains are developed termed **Actual or Alpha Grains.** This applies both to the ferrite and pearlite areas. In figure 18 can be seen the same grains of ferrite. In figure 19 is shown the structure of a .60 carbon steel showing both the actual (small) grains and the austenitic grains (white boundary markings).

✦ ✦ ✦

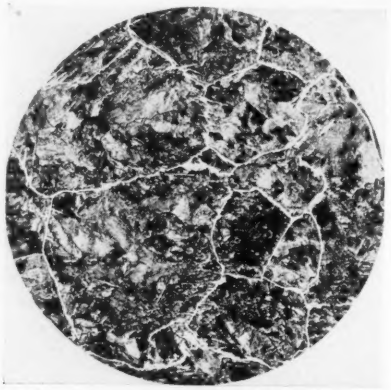
Reactions on Heating Steel

UP to this point we have discussed the changes which take place on cooling. When steel is heated the reactions previously described are reversed. As the temperature passes the line PSK the Pearlite transforms to Austenite and on further heating, the free ferrite or cementite, depending on the analysis, is dissolved in the austenite. This solution of the excess constituent alters the carbon content of the austenite until at the lines GSE, we have a solid solution of carbon in Gamma Iron with a carbon content in line with the amount present in the steel.

✦ ✦ ✦

Influence of Fast Heating and Cooling Rates

ALL of this discussion thus far, pertains to a rate of heating or cooling slow enough to allow time for the various changes to take place, whether it be solution or precipitation. If, however, we increase the rate of heating or cooling, the temperature at which the reactions take place may be higher on heating or lower on cooling. The extent to which they vary from the phase boundary lines GS, SE and PSK shown in figure I, depends on how much removed the rate of heating or cooling is from that required for equilibrium. If for example, a thin piece of .50 carbon steel is heated suddenly, as by means of electrical resistance, the temperature of the steel itself may be higher than 1450°F before the ferrite is completely dissolved, that is before the line GS is passed. In the same manner if we suddenly quench a piece of .50 carbon steel in water from a temperature of 1700°F the temperature of the metal may be considerably lower than 1333°F before the transformation associated with the line PSK takes place. Both the Iron-Carbon



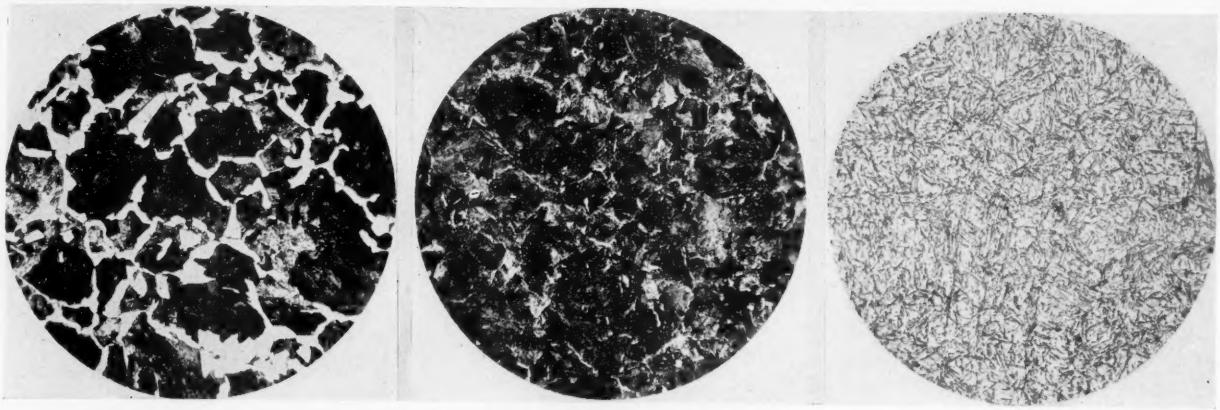
.60 Carbon Steel Showing both Alpha Grains (Black Boundary Line) and Austenitic Grains (White Boundary Markings). Magnification 200X.

FIGURE 19

Diagram (Figure H) and the Iron-Iron Carbon Diagram (Figure I) are based on only the influence of carbon additions to Iron. Other elements, such as Manganese, Chromium, Nickel, etc., influence the temperature at which these reactions occur. This is particularly noticeable in the case of high Chromium and High Nickel Steels, even in plain carbon steels however, variations as much as 75°F may be encountered. Manganese for example lowers the line PSK (Figure I) on cooling to approximately 90°F for each percent present.

✦ ✦ ✦

TO distinguish between heating and cooling of steels the two letters c and r are employed. For example, the line GS has the designation A_3 and the line PSK A_1, this is for the purpose of the diagram based on equilibrium. When, however, we refer to the heating



(a) Annealed Structure Cooled in Furnace (b) Normalized Structure Cooled in Air. (c) Quenched Structure Quenched in Oil

	(a)	(b)	(c)
Tensile Strength lbs. per Sq. Inch	118,000	147,000	Not Determined
Hardness—Rockwell "C" Scale	26	34	63

¼" Steel Rod .65 Carbon all photomicrographs taken at 200X.

FIGURE 20

of steel the letter c is placed after the letter A and on cooling, the letter r. On heating, therefore, we refer to the lines PSK as Ac_1, and the line GS as Ac_3. On cooling the line GS is referred to as Ar_3 and the line PSK as Ar_1. In the same manner the line SE designated as Acm is referred to as Ac_{cm} or Ar_{cm}.

✦ ✦ ✦

BECAUSE of the small influence that the normal heating of steel has on the position of the Ac_1 or Ac_2 no particular reference need be made to these lines on heating. It is well to bear in mind however, that they can be affected and when small sections are allowed to come to temperature quickly time should be allowed to insure complete solution. Because of the wide range over which Ar_1 and Ar_3 can be varied and the influence these variations have on the metal, we can well afford to study the effect of cooling rates on the position of these lines.

✦ ✦ ✦

IN general, the rate of cooling of steel has three prime classifications:

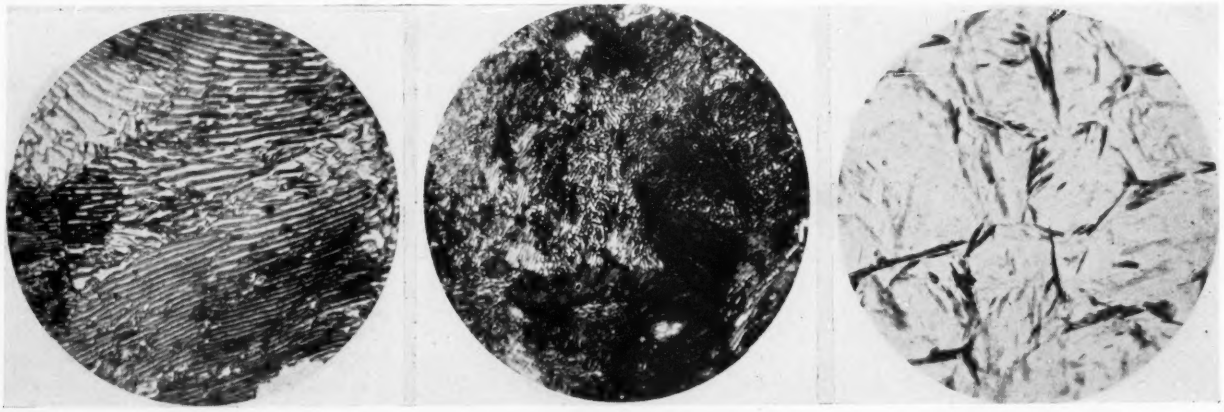
Annealing
Normalizing
Quenching

✦ ✦ ✦

THE term **Annealing** is employed to indicate slow cooling, as for example allowing the steel to cool with the furnace. The term **Normalizing** is employed to indicate an intermediate rate, where cooling is neither retarded nor hastened appreciably, as cooling in air. **Quenching** is employed to indicate rapid cooling, as in water or oil.

THE size of the piece being cooled will have a decided influence on the position of the Ar_1 transformation because of the **Mass Influence.** Inasmuch as the heat contained in the piece must of necessity diffuse out to affect cooling, the greater the amount of surface area the faster will be the rate of diffusion. Thin sections will therefore cool more quickly than thick sections because of the greater amount of surface for the quenching medium to act on and will require a less drastic quench. It should be remembered however, that the lowering of the Ar_1 is a direct function of the rate of cooling regardless of the mass influence.

✦ ✦ ✦



(a) Annealed Structure (b) Normalized Structure (c) Quenched Structure

Same as Shown in Figure 20—Only at 2000X.

FIGURE 21

IN figure 20 is shown the microstructures resulting from the three methods of cooling described above, employing a .65 carbon steel rod ¼" in diameter. The tensile strength and rockwell hardness of these samples are also given. a is the annealed structure, note the network of free ferrite. b is the normalized structure, note the small amount of network structure as compared with a. This sample was air cooled. c is the structure resulting from cooling in oil.

✦ ✦ ✦

IN figure 21 a-b-c is shown the same samples at a magnification of 2000 X. Note the difference in the fineness of the Pearlite between a and b.

✦ ✦ ✦

Sub-Critical Transformation

AS the rate of cooling is increased the temperatures of both the Ar_3 and Ar_1 transformations will be lowered, as shown by the dotted lines in figure I. The reason for this, as previously discussed, is that time is required for these changes to take place, and if the temperature of the metal is lowered quickly the lag in transformation will result in the metal being at a temperature much lower than 1330°F (line PSK—figure I) before the Ar_1 transformation has occurred.

✦ ✦ ✦

WHEN, as a result of fast cooling, the Ar_1 transformation temperature is lowered, diffusion of the carbide, which precedes precipitation is interfered with and the precipitated particle will be reduced in size in proportion to the degree of lowering of the temperature at which transformation occurs.

✦ ✦ ✦

IN a hypo-eutectoid steel on a slow cooling we have a structure consisting of pearlite with the excess constituent, free-ferrite, precipitated at the boundaries of the austenitic grains, which existed prior to the transformation. If the rate of cooling is increased, the thickness of the plates of cementite and ferrite of the pearlite will be reduced and the amount of free-ferrite precipitated at the old austenitic-grain-boundaries will be decreased. Further lowering of the Ar_1 transformation temperature may prevent the precipitation of free ferrite at the old austenitic-grain-boundaries and it will be found intimately mixed with the Pearlite. As the temperature of transformation is still further lowered the decrease in plate thickness and particle size of the ferrite will continue until a point is reached at an Ar_1 transformation temperature of approximately 350°F, where there is no precipitation and the Iron-Carbide is held in solution in the ferrite.

✦ ✦ ✦

THE fact that transformation has occurred however, indicates that the change from Gamma (face centered cubic space lattice) to Alpha Iron (body centered cubic space lattice) has taken place and we have a solid-solution of Iron-Carbide in Alpha Iron.

✦ ✦ ✦

UNDER the microscope this material has a characteristic needle-like structure and is metallographically termed **Martensite,** see figures 20-C, 21-C and 23-A. Because of a complex atomic arrangement and also probably due to a distortion of the space lattice resulting from the retention of Iron-Carbide in solution in Alpha Iron, Martensite is extremely hard.

✦ ✦ ✦

WHEN steel is cooled at a rate slow enough to result in the Ar_1 transformation occurring above 350°F the plate-like structure of pearlite will prevail. As previously stated the plate thickness may vary, depending on the temperature of transformation but because of the tendency for the direct precipitation from austenite to occur along crystallographic planes, regardless of the plate thickness, this tendency towards stratification will persist. When the rate of cooling is fast enough to affect a sufficient lowering of the Ar_1 transformation temperature to cause it to occur below 350°F martensite is formed and we have what is termed a **Critical Quench** or **Critical Quenching Rate.**

FROM the above it is apparent that the transformation product of austenite can be either pearlite and ferrite, or martensite, that is, we may have either of the following reactions.

Austenite→ Pearlite and Ferrite
Austenite→ Martensite

✦ ✦ ✦

Reaction Rate

THE rate at which the transformation from austenite to ferrite and pearlite takes place is termed the **Reaction Rate.** As the temperature at which the Ar_1 transformation occurs is lowered the reaction rate will be decreased. Steels having a coarse austenitic grain size above the upper critical (line GSE figure I) will tend to cause a lowering of the transformation temperature as compared with steels having a fine austenitic grain size, employing the same rate of cooling. Coarse austenitic grains therefore produce a slow reaction rate as compared with fine austenitic grains. Certain elements also influence the reaction rate, oxygen for example tends to produce a fast reaction rate while carbon and manganese tend to produce a slow reaction rate.

✦ ✦ ✦

THE temperature from which cooling begins also influences the reaction rate. This is due however, to an accelerated cooling rate for steels cooled from the higher temperatures rather than any tendency to promote the precipitation of ferrite and pearlite. Other conditions being the same, the higher the temperature from which cooling begins, the slower the reaction rate.

✦ ✦ ✦

THE time required to complete the austenite → ferrite and pearlite reaction has been the subject of exhaustive studies by Bain and his associates and it has been shown that the time for reaction varies with the temperature at which the transformation takes place. At an Ar_1 transformation temperature of 700°F, for example, the time required to complete this reaction will be approximately 7 minutes. With a lowering of the transformation temperature to 500°F approximately 1 hour will

be required. Further lowering will so increase the time required as to extend it to one week at a transformation temperature of 300°F. This change in reaction time varies slightly but for our purpose the above figures serve as a guide.

✦ ✦ ✦

THIS delay in reaction, or increase in the time required to complete the reaction, as the temperature of reaction is lowered is undoubtedly due to the greater rigidity at lower temperatures and its influence on diffusion rate. Regardless of the length of time required, however, if the temperature of the steel is maintained above 350°F the reaction Austenite→ Ferrite and Pearlite will take place throughout. The plate thickness of the Pearlite may be so reduced as to make it unresolvable at the highest magnifications, but we still have the tendency towards stratification.

✦ ✦ ✦

IN studying the effect of lowering the temperature of transformation, a molten metal or lead bath is employed as a cooling medium. The size of the piece being treated has a decided influence on the cooling rate. Thick sections because of mass influence, will not produce the same degree of lowering of the Ar_1 as will thin sections where the heat is more quickly dissipated. Bain and his associates have shown that by deliberately holding the metal at a given subcritical temperature above 350°F long enough to complete the transformation of Austenite some remarkable physical properties can be developed.

✦ ✦ ✦

IF, instead of holding at a given sub-critical temperature, above 350°F, long enough to complete transformation of the austenite, the piece is removed before transformation is completed and quenched in water, the structure of martensite will be found in the untransformed areas. (See figure 24). We will then have present in the structure the products of both the **austenite→ferrite and pearlite** and **austenite → martensite reactions,** or a **Split** in the **Transformation** of Austenite. In figures 22, a, b and c is shown three photomicrographs of split transformation structures. The white areas in each case is martensite while the dark areas consist of fine pearlite. These structures represent three degrees of lowering of the Ar_1 followed by cooling in water. Note how the amount of martensite varies with the varied rate of cooling. (See also figure 24).

✦ ✦ ✦

THE split transformation can only occur when the rate of cooling, that is the degrees drop per second, is faster than the time required to complete the Austenite →Pearlite and ferrite reactions. As has already been shown it occurs between an Ar_1 transformation temperature of 900°F to 350°F approximately. Below 350°F precipitation is prevented and Martensite is formed. When the cooling is such that the Ar_1 occurs above 900°F the rate of cool is slow enough to permit time for the completion of the reaction. Slower cooling, which produces a transformation temperature higher than 900°F only increases the plate thickness of the Pearlite as previously shown.

✦ ✦ ✦

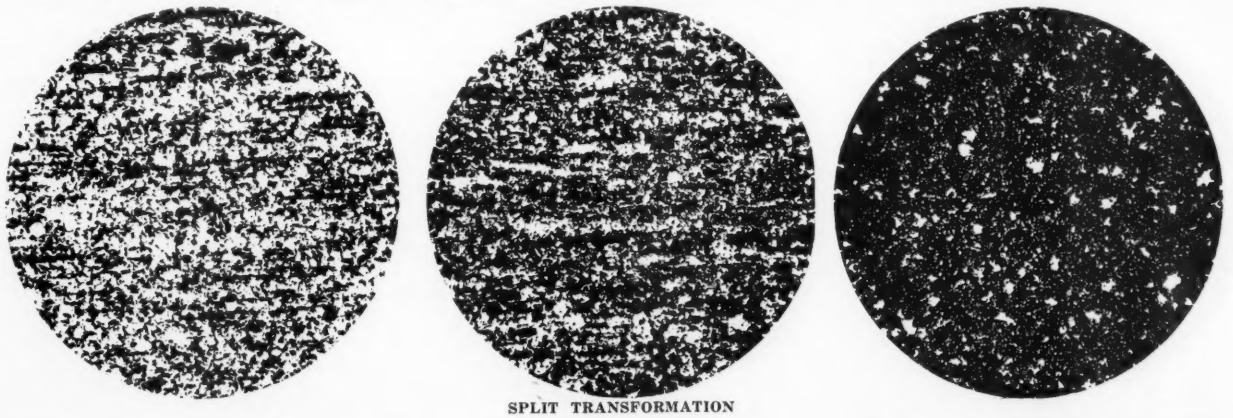
FOR some time the transformation of Austenite was believed to occur in the following manner:

Austenite→Martensite →Troostite →Sorbite→Pearlite.

✦ ✦ ✦

AS has been shown, Austenite transforms to Pearlite or Martensite only. Troostite and Sorbite can be considered transformation products of Martensite. However, recent work has clearly shown that at no time is Pearlite the end product of Martensite but that all Pearlite is a product of the Direct Austenite → Pearlite transformation. This transformation provides opportunity for precipitation along crystallographic planes of the Austenite and makes possible the tendency towards stratification or formation of plates. The precipitation associated with the transformation of Martensite is not of this nature because the crystallographic planes of the Austenite are absent in the Martensitic structure. As a result of this the carbide precipitation from Austenite is independent of crystallographic plane influence.

✦ ✦ ✦



SPLIT TRANSFORMATION

(a) Large amount of Martensite (White), small amount of Pearlite (Dark). ✦ ✦

(b) About half Martensite and half Pearlite. ✦

(c) Large amount of Pearlite, small amount of Martensite. ✦ ✦ ✦

All Taken at 200X

FIGURE 22

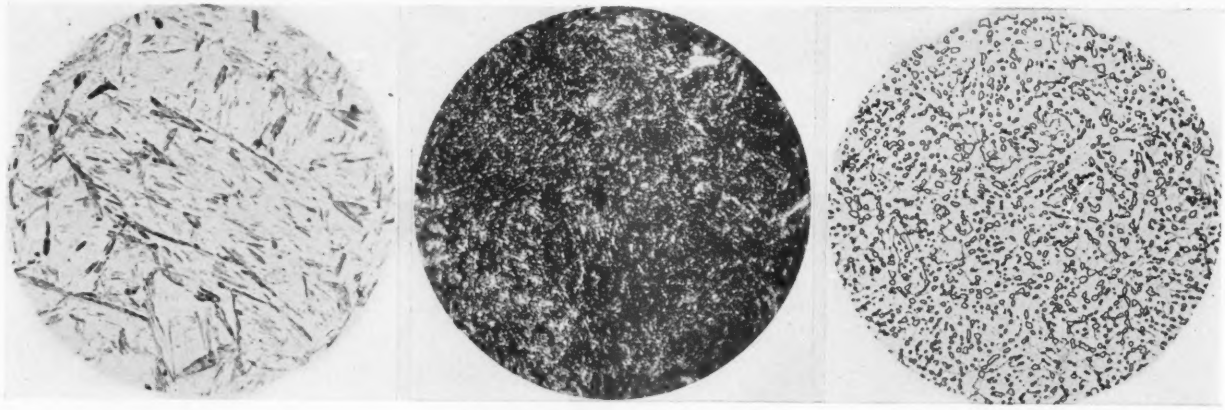
Tempering

AS previously shown, the line PSK (see figure I) corresponding to 1333°F represents the lowest temperature at which Iron-Carbide is soluble in ferrite also this line represents the transformation from Gamma to Alpha Iron. If, therefore, Iron-Carbide is held in solution in Alpha Iron at room temperatures it is obvious that an unstable condition prevails and that there is a tendency for the Carbide to precipitate, because it is held in solution at a temperature some 1200°F lower than its normal precipitation temperature. As a result of this, on reheating Martensite to about 400°F, Iron-Carbide, in the form of very fine rounded particles, precipitates. The first precipitation thus formed is extremely fine and contains a large amount of surface tension forces seeking relief. On reheating to higher temperature the fine particles coalesce to form larger particles thereby reducing the total amount of particle surface. On continued raising of the temperature coalescense continues until on long exposure at a temperature of 1300°F the Iron-Carbide will be present in the steel in relatively large rounded particles in a matrix of ferrite. We have therefore the transformation, Martensite→ Ferrite and Cementite, as a result of reheating or **Tempering Martensite.**

✦ ✦ ✦

IN figure 23—a, b and c is shown three photo-micrographs pertaining to the transformation of Martensite. (a) is the original structure of Martensite (b) is the structure produced by reheating (a) for ten minutes at 850°F, while (c) shows the structure which results from heating (b) for 12 hours at 1300°F.

✦ ✦ ✦



TRANSFORMATION OF MARTENSITE

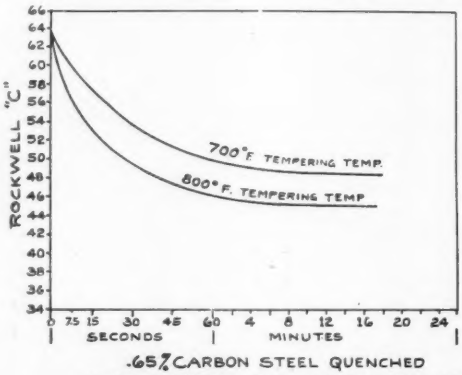
(a)
Martensite. Rockwell Hardness C-64. ✦

(b)
After reheating (a) to 850°F for 10 minutes—fine particles of Iron-Carbide. Rockwell Hardness C-49. ✦ ✦ ✦ ✦

(c)
After reheating (a) to 1300°F for 12 hours—coalesced particles of Iron-Carbide in a Matrix of Ferrite. Rockwell Hardness C-22. ✦

All Taken at 1000X.
FIGURE 23

BECAUSE of a complex atomic arrangement and the presence of a considerable amount of force seeking relief, Martensite is extremely hard. On reheating, much of the strain is relieved; the hardness is decreased and there is a gradual-softening of the steel as the tempering temperature is raised. In figure 23 is also shown the Rockwell hardness values of the three samples photographed.



.65% CARBON STEEL QUENCHED AND TEMPERED FOR VARIOUS PERIODS OF TIME
FIGURE J

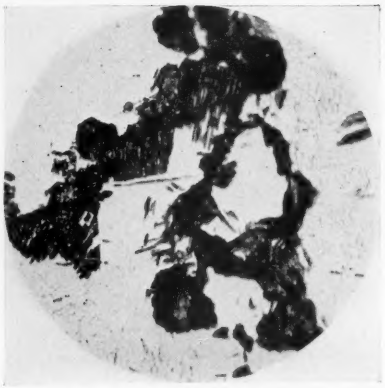
✦ ✦ ✦

IN tempering, it is important that sufficient time at temperature be allowed to establish equilibrium, as in the case of grain growth, time is required to establish a particle size in line with the temperature, if the time at temperature is too short the physical properties, which reflect the heating influence only, will be in line with a tempering temperature lower than that actually employed. The curves in figure J show the manner in which the hardness decreases as the time at the tempering temperature is extended until a point is reached where the time balances with the temperature at which point further extension of time does not reduce the hardness.

✦ ✦ ✦

THE term **Troostite** has been applied to the type of structure shown in figure 24 which is the split transformation and the early development of rounded precipitated particles of Iron-Carbide, produced by tempering Martensite. See figure 25, which represents the structure of a .60 carbon steel quenched and tempered to 550°F.

✦ ✦ ✦



Split Transformation. Dark Area Previously Termed Troostite, More Recently, Fine Pearlite. Taken at 2000X. ✦ ✦ ✦

FIGURE 24

SORBITE was supposedly a further stage in the transformation of Martensite corresponding with the reheating of Martensite to temperatures between 800°F and 1200°F—see figure 23-b.

✦ ✦ ✦

AT the time this story is written a state of chaos exists as to the proper definition of these two terms and there is a possibility that either or both may be dropped from the metallographic nomenclature.

✦ ✦ ✦

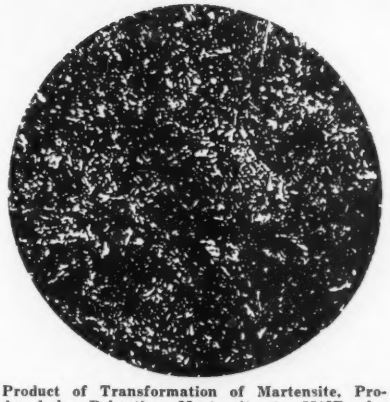
Spheroidizing

THE product of the extended heating of Martensite as shown in figure 23-c, is spheroidal particles of cementite in a matrix of Ferrite and this structure is termed **Spheroidized or Globular Cementite.** The **Spheroidizing Treatment** is that shown for this sample, namely: holding at or slightly below the phase boundary temperature PSK (1333°F) for an extended period of time. This provides for almost complete relief of the forces of surface tension and reduces grain boundary material, it represents the softest state that can be developed in steel of a given analysis. While as shown, Spheroidizing can and usually is, produced from a Martensitic structure prolonged heating of pearlite will afford similar relief of surface-tension forces because the plate-like structure of pearlite will break down on prolonged heating at or slightly below 1330°F and form spheroidial particle of cementite in a Matrix of Ferrite. In figure 26 is shown three stages in this development (a) is the original pearlite structure (b) after heating (a) for 6 hours at 1300°F, (c) is the structure produced by heating (a) for 16 hours at the same temperature.

✦ ✦ ✦

TEMPERED steel, because of the amount of boundary material associated with the fine particles, will etch out quickly and appear dark under the microscope. As the tempering temperature is raised however, and the particle size increases, the structures will appear less dark, when examined, because of the reduction of the amount of boundary material associated with particle growth. (Compare b and c—figure 23).

✦ ✦ ✦

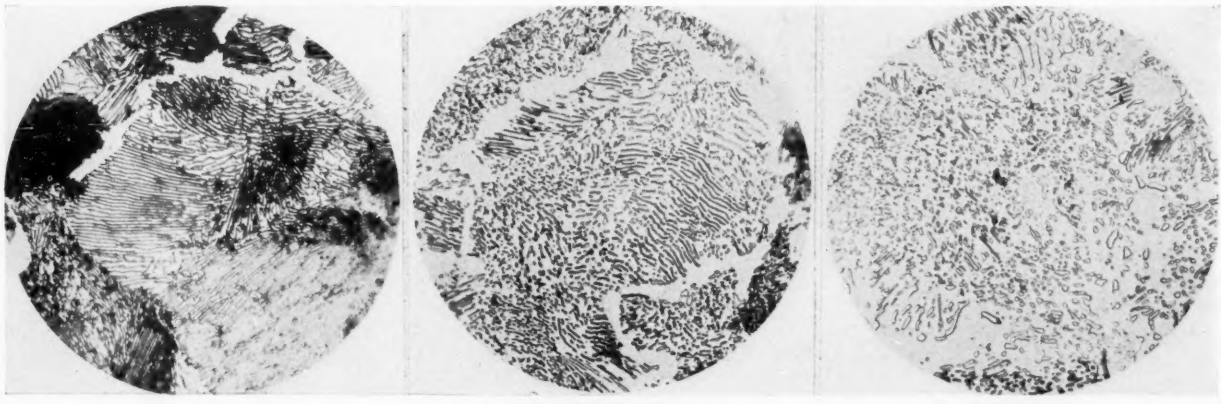


Product of Transformation of Martensite. Produced by Reheating Martensite to 550°F also termed Troostite. Magnification 2000X. ✦

FIGURE 25

Influence of Austenitic Grains

WHEN the steel is cooled from above the line GSE (see figure I), the tendency for particles to precipitate at the austenitic grain boundaries may be restricted because of the rate of cooling, as previously described. There is this tendency present however, which is never completely overcome and, even in steels quenched at a rate which will produce Martensite, there is sub-microscopic material at the locations of the old Austenitic Grain boundaries which serve to retain, in varying degrees, the identity of the original austenitic grains. When steel is alternately stressed lightly as in fatigue, it is not uncommon for these stresses to be of an order which influence the old austenitic grains only and not sufficient to effect the grain material proper. This concentrat-



REHEATING PEARLITE

(a) Original Pearlitic Structure. ✦ ✦ (b) After Reheating (a) for 6 hours at 1300°F. (c) After Reheating (a) for 16 hours at 1300°F.

All Taken at 1000X

FIGURE 26

ing of stresses induces failure, and the characteristic crystalline appearance often associated with fatigue fractures is a result of ruptures occurring along the old austenitic grain boundaries. To avoid or reduce failure from this source, it is advisable to keep the austenitic grain size as small as possible in steels to be quenched and tempered, thereby providing a better distribution of strain. This is done by employing as low a temperature as possible in heating prior to quenching.

✦ ✦ ✦

WHEN the steel is heated, the grain size undergoes a decided change as the line Ac_1 is passed and remains in a more or less structureless stage until complete solution of the constituents are effected, or until the steel has passed the Ac_3. Above this point the austenitic grains are formed and as the temperature is raised they grow, by the combination of small grains to form large ones. If, therefore, we keep the temperature of the steel to be quenched, as near to the line GSE as will produce the desired quench effect, we will have the minimum Austenitic grain size influence.

✦ ✦ ✦

McQuaid Ehn Grain Size Test

ALL steels do not have the same grain growth tendencies in the austenite. For many years the fact that two heats of steel of identical chemical analysis would vary in hardening effect under identical conditions of quenching was commonly known, not until the publication of a paper by Messrs. McQuaid and Ehn before The American Institute of Mining & Metallurgical Engineers in 1922 however was the reason for this variation understood.

✦ ✦ ✦

IN this paper the authors pointed out that by employing a fixed treatment which consisted of carburizing the steel to be tested for 8 hours at a temperature of 1700°F, followed by slow cooling, the network of cementite, which precipitated out at the austenitic grain boundaries, served as markings and indicated a wide variation in different steels in the tendency for the austenitic grains to grow. As a result of their work, a series of grain size numbers have been developed and accepted by the American Society for Testing Materials and others, based on the counting or estimating of the number of grains per square inch when the specimens, prepared according to the **McQuaid Ehn Grain Size Test** procedure outlined above, are examined under the microscope at 100 magnifications. These numbers range from 1 to 8. The range of grain size embraced by each number is shown below:

TABLE II

McQuaid-Ehn Grain Size Numbers and Number of Grains per S. Inch embraced by each when observed at 100 X
1 - up to 1½
2 - 1½ to 3
3 - 3 to 6
4 - 6 to 12
5 - 12 to 24
6 - 24 to 48
7 - 48 to 96
8 - 96 and over

STEELS are usually classified by the general terms, "coarse grain" or "fine grain". **Coarse Grain Steels** are steels which show from 1 to 5 grain size numbers inclusive or 0 to 24 grains per sq. inch at 100 X, while **Fine Grain Steels** are those with grain size numbers 6 to 8 inclusive or 25 to over 96 grains per sq. inch at 100 X.

✦ ✦ ✦

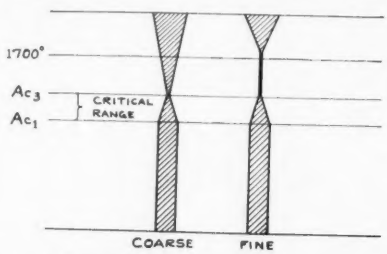
IN figure 27 is shown a sample of coarse and fine grain steels produced according to the test procedure described.

Coarse Grain Steel. 4 Grains per Sq. inch at 100X. Fine Grain Steel. 80 Grains per Sq. inch at 100X. Produced according to the McQuaid-Ehn Grain Size Test. Both taken at 100X ✦ ✦

FIGURE 27

✦ ✦ ✦

THIS test serves to indicate the grain growth tendencies of the steel above the line GSE. The fact that at 1700°F, the temperature at which the steel was held, no appreciable grain growth had developed in the fine grain steel, as compared with the coarse grain steel, indicates a delay in growth tendency. Grain growth and the influence of fine or coarse grain steel as determined by this test, can best be visualized by referring to Figure K. At the line Ac_1 as shown in this figure, which corresponds to the line of the same designation in figure I, the rearrangement of the atoms produces a negative grain size. Between Ac_1 and Ac_3, in this drawing, solution of the excess constituent is going on and the grain size remains negative. Above this line however, the austenitic grains are formed and start to grow. In the case of the fine grain steel growth is retarded until a temperature above 1700°F is passed. In the



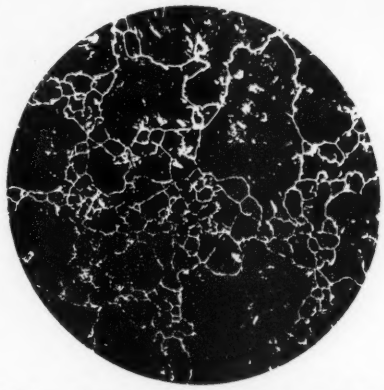
CHANGES IN GRAIN SIZE AND GRAIN GROWTH TENDENCIES BETWEEN COARSE AND FINE GRAIN STEELS.

FIGURE K

coarse grain steel growth starts immediately after the line GSE is passed. This growth follows along the lines previously discussed; that is, it progresses due to the forces of surface tension overcoming the rigidity, and as the temperature is further raised, growth will continue.

✦ ✦ ✦

WHILE in the past the extreme range in grain sizes was not commonly experienced, there was a decided tendency for steels to show what is called **Duplexing,** that is, fine and coarse grain areas mixed. In figure 28 is shown a typical duplex structure. The presence of this condition in steel is extremely harmful because on cooling we have both fine and coarse austenitic grains.



Duplex Structure. Showing Coarse and Fine Grains Mixed Produced according to the McQuaid-Ehn Grain Size Test. Taken at 100X. ✦

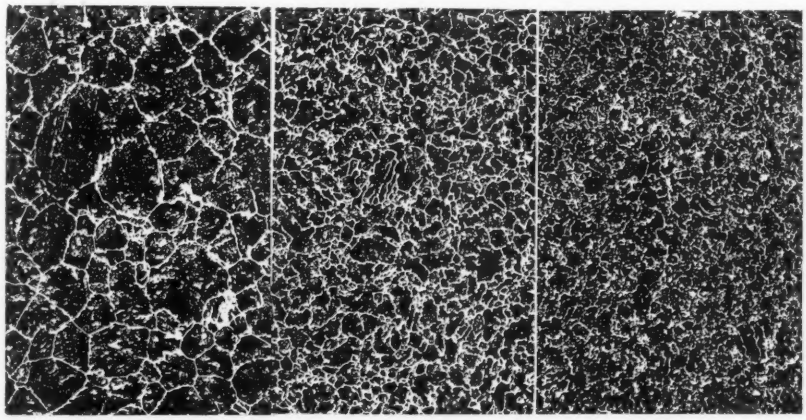
FIGURE 28

✦ ✦ ✦

AS has previously been shown the Austenitic grain size of the steel just prior to cooling has a decided influence on the rate of reaction. If, therefore, we have both fine and coarse grains, as in the case of a duplex steel shown by the McQuaid Ehn Grain Size Test, we will have both slow and fast reaction rates in the same piece. This will influence the precipitate of Iron-Carbide differently in different areas and produce variations in the thickness of the plates of Ferrite and Cementite when the rate of cooling is less than that required to form Martensite. If the cooling rate is fast enough to form Martensite, the influence of fine and coarse Austenitic Grains in the same piece are not apparent.

✦ ✦ ✦

THE factor that influences the fineness or coarseness of steels as determined by the McQuaid Ehn Test is the temperature at which grain coarsening, called the **Grain Coarsening Temperature,** occurs. The very fact that in fine grain steels the fineness persisted until 1700°F was reached, indicates that the grain coarsening temperature in this case is above 1700°F. Coarse grain steels have a grain coarsening temperature below 1700°F. The temperature at which the grains coarsen is a function of the metal and not the treatment, that is, whether a steel is coarse or fine grain according to this test, goes back to the steel making practice. Hot Rolling, Cold Working and special heat treatments have an influence on the grain coarsening tendencies, these influences are slight however and not sufficient to seriously alter the grain size classifications of the steel.



No Aluminum Added. ✦ 6.5 Oz. of Aluminum per ton added. ✦ 13 Oz. of Aluminum per ton added. ✦

Produced according to the McQuaid-Ehn Grain Size Test. Taken at 100X. ✦

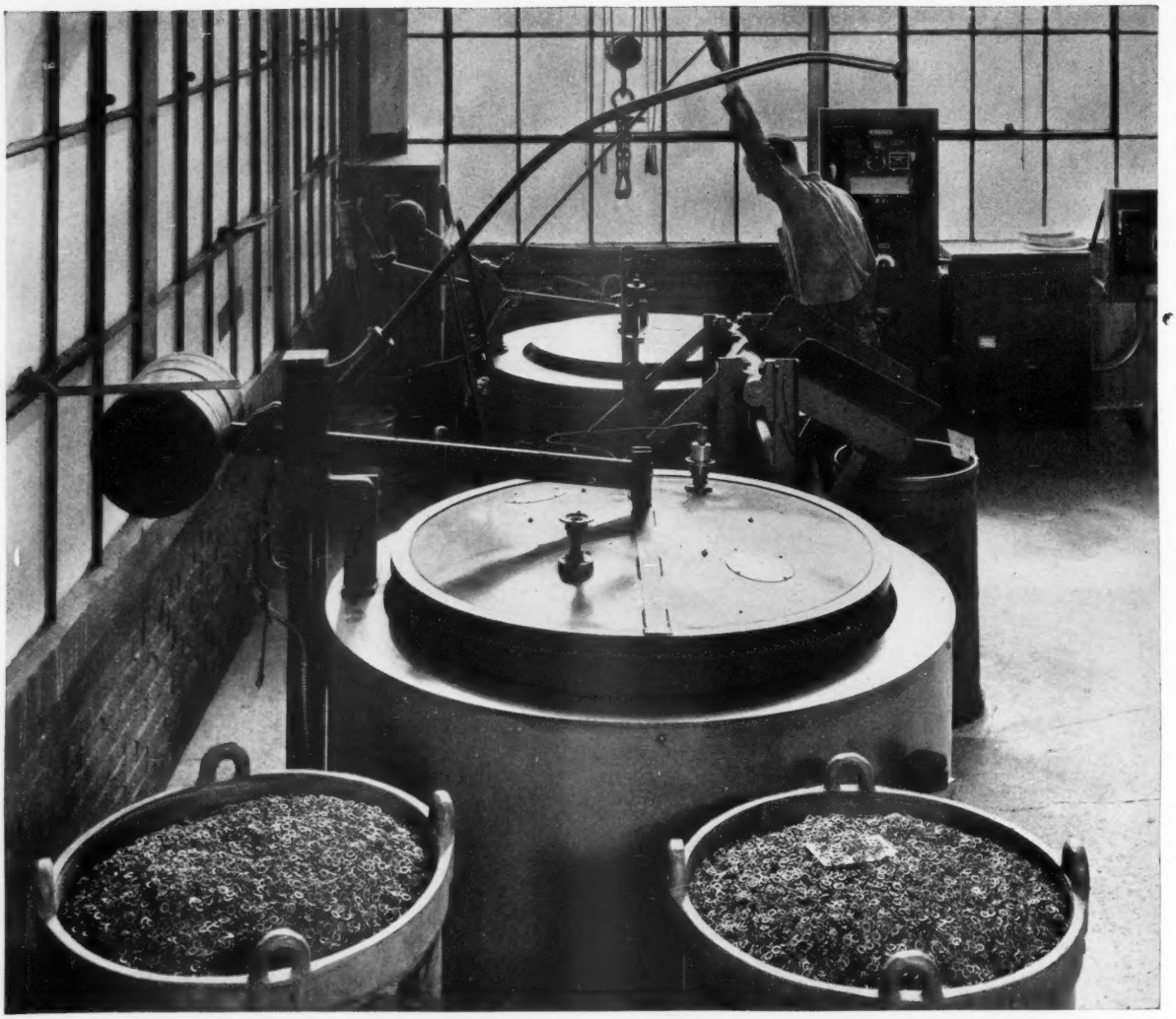
FIGURE 29

GRAIN size control, that is the control of the austenitic grain size, has to do with the nature of the charge, melting practice and deoxidation. Under proper condition of steel making the product will be coarse grain. The control of fine grain steels is affected by the addition of aluminum. An example of the influence of additions of aluminum on the grain size of a given steel is shown in figure 29. In this case the aluminum was added to the mold of the same heat so that the influence of aluminum could be isolated and determined.

✦ ✦ ✦

A NUMBER of theories have been advanced to account for the control of grain size. Chief among these is the obstruction to grain growth afforded by the presence of numerous submicroscopic particles of Al_2O_3 in suspension in the metal at time of cooling. The theory being that these small particles act as nuclei for development of numerous small grains. Another theory and one which seems to have some worth is that the presence of aluminum in solid solution in the austenite produces a low energy aluminum-iron combination which contains less force and therefore requires a higher temperature or lower rigidity of the metal before the force or energy present overcomes rigidity and breaks down grain boundaries to form larger grains. The fact that an appreciable amount of aluminum over that required to deoxidize the steel is essential to the production of fine grain steels, seems to lend strength to this latter theory.

(*Please turn to Page 750*)



Installed years ago, the Homo Furnace in the background was recently given a modern heater and blower. It now tempers dense loads of lock washers as efficiently as the new Homo in the foreground.

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J-T625(11)

The Fabrication of Bi-Metallic Wire

By Charles M. Wilson,

Assistant Director, Chicago Police Scientific Crime Detection Laboratory; formerly Assistant Professor of Police Science and Research Engineer, Scientific Crime Detection Laboratory, Northwestern University School of Law.

This is part II of the article published in the September issue of "WIRE & WIRE PRODUCTS" under the title, "The Comparison and Identification of Wire in A Coal Mine Bombing Case". This is a study of the process of manufacturing bi-metallic wire which it was necessary to make before the method of identifying the wire as outlined in part I could be followed. ✦ ✦ ✦ ✦ ✦

IN general, the manufacturing processes used in the production of many types of wire such as copper, brass, iron, bronze, aluminum, etc., closely follow the practices employed in the fabrication of copper and copper-coated steel wire. The control studies undertaken in the preparation of this case were, however, confined to copper, copper-clad and copperweld wire.

✦ ✦ ✦

COPPER-COATED steel core wire has been produced in this country by several manufacturers and by various processes. The Duplex Metals Company produced a wire of this type until 1910-11. The Standard Underground Cable Company produced a copper-steel bimetallic wire known as "copper-clad" but its manufacture was discontinued in 1928-29. Since that time a similar type of wire has been produced by the Copperweld Steel Corporation of Pennsylvania, "copperweld" being the trade name applied to the copper-coated steel core material made by the molten-welding process.

✦ ✦ ✦

HOT rolled copperweld rods are supplied to the wire mills of a number of other manufacturers who, like the Copperweld Steel Company, cold draw the rod to form wire in various sizes. The copperweld material is formed into rods, wire, nails, and similar products in which a protective exterior coating of electrolytic copper is molten welded to the steel core.

THE first step in the manufacture of this material is the forming of a cylindrical steel billet approximately 48″ long and 7″ in diameter. After cleaning and fluxing, the steel billet is centered in a circular mold which has an inside diameter of approximately 9″. After sealing the top, the mold and the steel billet are placed in a furnace and heated. When the mold and billet have reached the proper temperature they are removed and molten copper is poured into the space between the steel billet and mold, thus forming a composite bimetallic ingot weighing approximately 260 pounds (see Figure 13). The manufacturers of this material claim a true weld between steel and copper by interlocking the crystalline structure of the two metals.

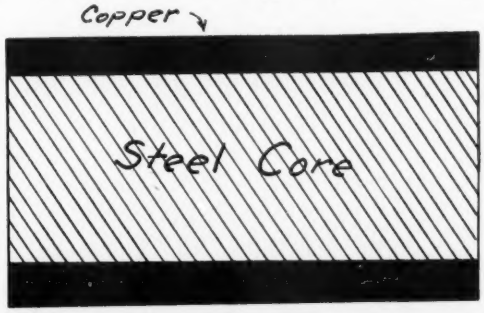


Figure 13. Transverse cross section diagram of bi-metallic ingot formed as first step in manufacture of copper-clad or copperweld wire.

✦ ✦ ✦

THE older, now obsolete, process of producing copper-clad ingots differed from the copperweld process essentially in that instead of molten-welding the copper to the steel core, a seamless copper tube was formed, and after being heated, was shrunk on the steel core which had been cleaned and fluxed. In this way a composite, bimetallic ingot was formed, having a copper jacket surrounding a steel core.

✦ ✦ ✦

IN the process of producing either copper-clad or copperweld wire the copper-steel bimetallic ingot is hot-rolled (Fig. 14) so as to form a ⅜″ circular bimetallic rod. The fabrication of this bimetallic hot-rolled rod is accomplished in the following manner: The bimetallic ingot is heated to a dull red heat in a soaking pit or furnace and is then passed between steel rolls rotating in opposite directions (Fig. 14). In this hot, rolling operation the diameter of the ingot is decreased and the length increased. The successive passes of the rod being formed as between

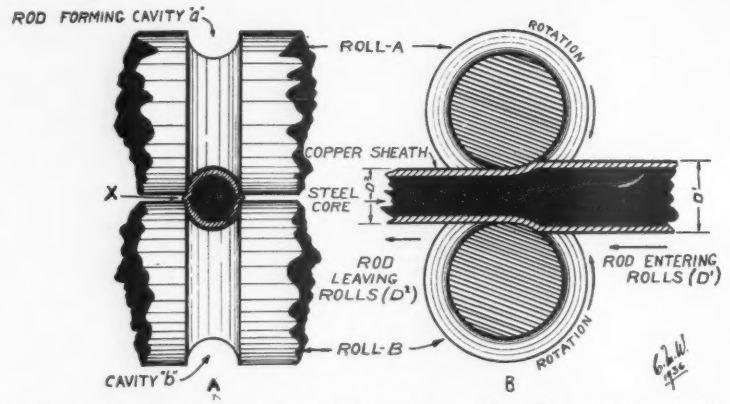


Figure 14. Diagrammatic representation of hot-rolling operation. By successive passes between rolls A and B, each set of rolls having cavities a and b of successively smaller diameter, is reduced to 3/8".

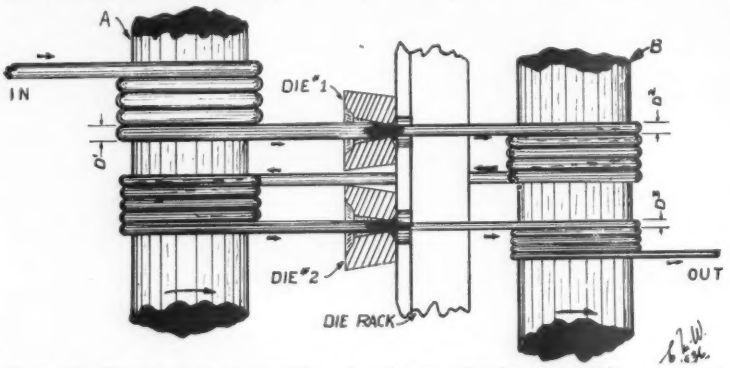


Figure 15. Diagrammatic representation of continuous wire drawing machine.

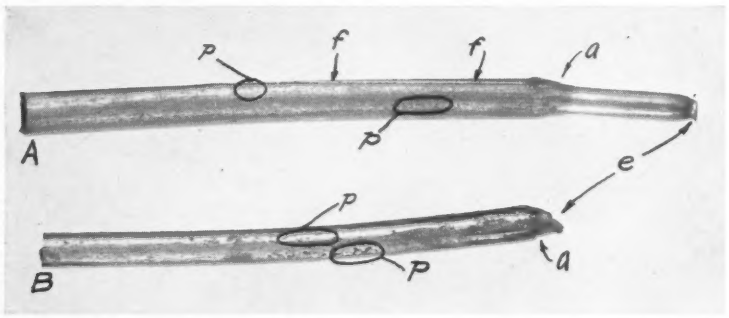


Figure 16. (A) Section of hot rolled copper rod which had been cold drawn to a. End e tapered to fractured end due to over-draft; f is fin raised in hot rolling; and p are microscopic pits due to pockets formed by scale being forced into rod. (B) Section of copper wire similar to (A).

rolls on the surface of which are semicircular cavities (*a* and *b*—Fig. 14); the radii of these cavities are such that they successively decrease the rod diameter, proportionately increase its length, and at the same time preserve its circular form. The final rolling cavities produce a 3/8" circular rod which is coiled and allowed to cool.

✦ ✦ ✦

THROUGHOUT the hot-rolling and subsequent cold-drawing operations the relation of the diameter of the steel core to the total thickness of the copper coating or sheath remains practically the same as in the original billet.

✦ ✦ ✦

THE 3/8" diameter circular bimetallic hot-rolled rod is cold-drawn to the desired size by repeatedly pulling or passing it through wire drawing dies which further successively decrease its diameter. In the diagrammatic illustration in Figure 15 the rod or wire enters the wire drawing machine and passes through wire drawing die #1 which reduces the diameter due to the plastic deformation occurring as the wire passes through the cone-shaped die throat. Upon leaving die #1, the wire, having a diameter indicated as D^2, is wrapped around a circular capstan or block (B) which, due to the traction between the wire and the rotating surface of the capstan, pulls the remaining wire through the die. The direction of movement of the wire is reversed by passing around capstan A, after which the wire enters die #2, whose diameter is such that the wire is again reduced (D^3) and then once more is wrapped around capstan B. Wire drawing machines are designed so that the die rack will accommodate a number of dies. As many as twenty drafts or reductions may be made in one machine.

✦ ✦ ✦

SINCE the reduction of the diameter of the wire proportionately increases its length, the wire will have a greater surface speed in leaving die #2 than the surface speed at which it entered die #1. This difference in surface speeds is compensated for by "stepping" or increasing the diameter of successive blocks or capstans in the direction of draw. In addition, the "slip" of the wire on the surface of pulling capstans tends to compensate for slight difference of capstan surface and wire speed.

✦ ✦ ✦

THE process of cold drawing of wire is a burnishing operation. Because of the plastic deformation or cold working of the wire incidental to increasing its length and decreasing its diameter, and also due to friction between die throat and the wire surface, considerable heat is evolved. The destructive effects of the heat thus generated are minimized and controlled by coating the surface of wire or rod entering a drawing machine with tallow or grease and in addition the wire, capstans, dies and die racks are either immersed in or sprayed with an emulsion of soap, oil, and water. This lubricates the wire and also assists in transmitting the heat away from the wire and dies.

THE cold drawing of wire hardens and increases the tensile strength of the metal being deformed or worked. This hardening limits the cold work that can be successfully undertaken before the metal must be restored to its original crystalline form by annealing or heating under the proper conditions of temperature and surrounding atmosphere. After annealing the rod or wire it is cooled. This important process alters the crystalline structure of the metal so that it ceases to be brittle and in effect restores the material to its original ductile form so that it can again be cold worked or drawn. The question of how often the wire must be annealed depends upon the physical and chemical properties of the metal, the speed at which it was drawn, the number of passes and the reduction per pass through each die.

✦ ✦ ✦

THE annealing leaves a surface accumulation of hard oxide or scale. Before the annealed wire can be drawn again this scale must be removed by pickling in a hot acid solution. This pickling process fails to completely remove the scale. Some of the particles adhere to the wire surface, some remain lodged in surface pits or pockmarks (P of Fig. 16) or are carried into the drawing die with the lubricating liquid in which wire and dies are immersed. The result of the combined effects of the abrasive or cutting action of particles of scale, dirt, etc., pulled into the die by the wire being drawn and the stresses incidental to the plastic deformation of the wire is to produce a rapid progressive alteration of that portion of the die surface which comes in contact with the wire (Fig. 17). From the time a die is placed in service these progressive changes of the die surface continue until the standards established by commercial practice force the wire mill to retire from service a die which will produce a wire which is off-size, out of round, brittle, or a wire whose surface contains certain objectionable defects. When a wire drawing die has been retired from service it is returned to the die shop and is lapped out or reshaped so it can again be used to draw a wire of larger size. This is particularly true of cemented carbide and diamond dies. If this were not done the cost of these dies would be prohibitive.

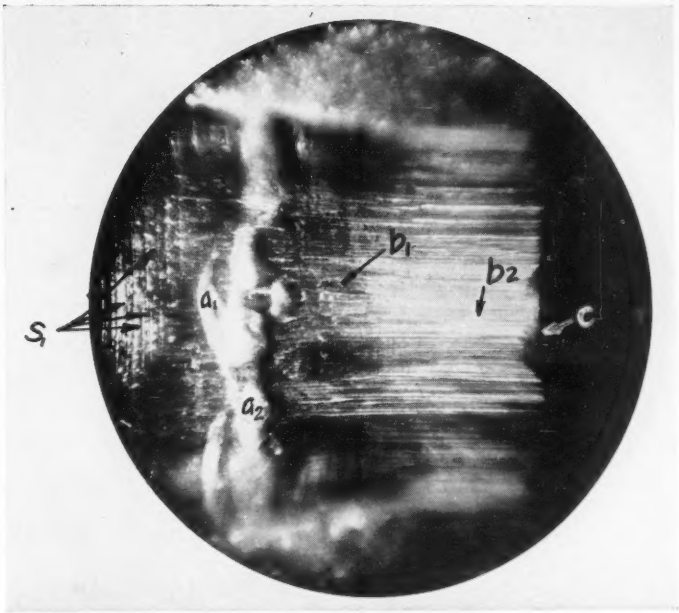


Figure 17. (A) Diagrammatic cross section of chilled iron wire drawing die before use. (B) Photomicrograph of portion of throat and bearing surface of chilled iron wire drawing die before use.

✦ ✦ ✦ ✦ ✦

✦ ✦ ✦

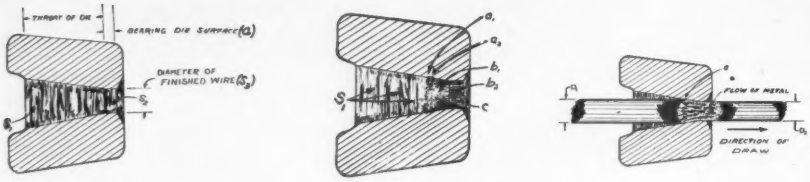
THERE are a number of different materials from which wire drawing dies have been made. Diamonds, steel, chilled cast iron, and carbides of titanium, tungsten and tantalum have all been successfully employed in making cold drawing wire dies. Because of the high initial cost, the use of diamond dies is largely confined to the drawing of the smaller sizes of copper wire. Carbide dies have come into very general use in the drawing of wire of many types. Chilled iron dies are extensively used in drawing the larger sizes of copper wire, and have been almost universally employed by the mills drawing copper-clad or copperweld wire.

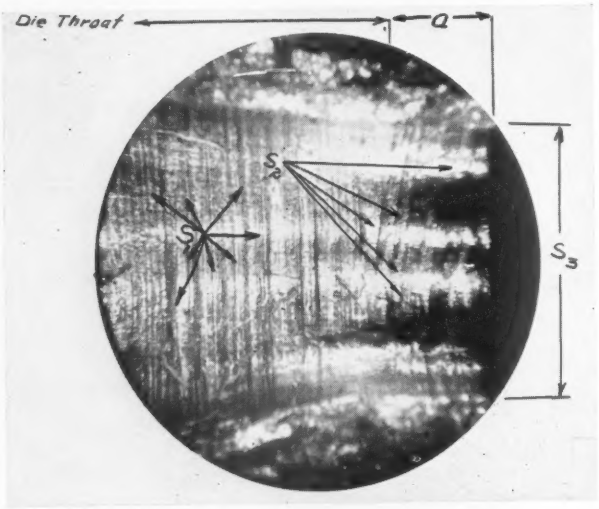
✦ ✦ ✦

IN forming or shaping a wire drawing die a circular or tapered hole is bored through the center of the nib or die blank (Fig. 16-A, B, C, D). In the case of diamond and cemented carbide dies this is an operation known as ripping and is performed in a machine which slowly rotates the die in one direction while a hardened steel wire or needle rapidly rotating in the opposite direction is raised and dropped in the center of the die. This steel wire or needle is charged with a mixture of oil and a powdered abrasive (Alundum, Crystalon, Carborundum, or diamond dust), which does the actual cutting. The result of this operation is to form a circular hole in the center of the die. After the circular hole has been formed the axis of the die is tilted with respect to the axis of the original hole and in the same machine the throat or tapering portion of the die is formed. The shape of the finished hole is then a right conical frustum (Fig. 17-A, C).

✦ ✦ ✦

AS has been pointed out, the forming of the wire cavity or throat in all types of dies by ripping, lapping or reaming is accomplished by rotating the die, the drill, or both. This leaves surface imperfections or striations which appear as annular rings in the die throat and bearing surface (S_1 and S_2 of Fig. 17-A, B, C, D).





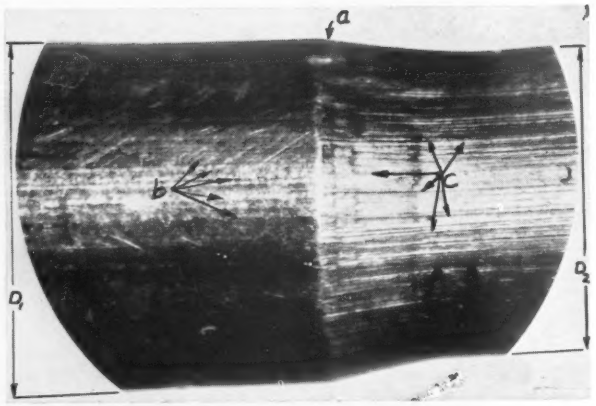


Figure 17. (C) Diagrammatic cross section of die after use in cold-drawing copper wire. (D) Photomicrograph, as in B above, after use.

Figure 17. (E) Diagrammatic cross section of chilled iron wire drawing die in use for cold-drawing copper wire. (F) Photomicrograph of surface of copper wire drawn by hand through chilled iron die to a and then pulled out of die in opposite direction to draw. Surface irregularities b due to characteristic imperfections of last die through which it was drawn to diameter D. Irregularities c due to characteristic imperfections of die reducing wire diameter to D_2.

IN the drawing of copperweld and copper-clad bimetallic wire, as has already been pointed out, chilled iron dies are almost universally employed. The cost of one of these die blanks represents only a few cents but the life of the die is very short compared to the life of carbide or diamond dies. It was found that the average life of the chilled iron dies when used to draw copperweld wire would run from 250 to 1000 pounds of wire before the die was no longer fit for service. When the same type of die is used in drawing pure copper wire its life was found to increase to form 500 to 2500 or 3000 pounds of wire. Carbide dies, when used to draw pure copper wire, could be expected to run 35,000 to 120,000 pounds of wire. When used to draw copperweld wire the carbide die life could be expected to run from 10,000 to 30,000 pounds of wire. Pure copper wire has been drawn through carbide and diamond dies at speeds up to 5000 feet per minute. Copperweld wire, being drawn from .128″ to .081″, travels at speeds from 900 to 1100 feet per minute. As might be expected, at surface ironing or burnishing speeds of this order there are relatively rapid progressive surface changes taking place on the die throat and bearing surface of the die which is cold working the wire. The control studies made confirmed this beyond any question of doubt (Fig. 17). Figure 17-B is a photomicrograph taken after breaking a chilled iron die which had been machined but had never been used to draw wire. Surface imperfections S_1, S_2 in the throat and bearing surface of die appear as annular rings and are the result of boring and reaming operations incidental to forming the die throat and bearing surface.

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FIGURE 17-D is a photomicrograph of the corresponding area of the same type of die (chilled iron) after being used to draw approximately 1000 pounds of copperweld wire. In that portion of the die throat which did not come in contact with the surface of the wire being drawn the original annular rings S_1, S_2 are retained at a_1 and a_2 and an irregular series of cavities will be seen. These correspond in the die throat with the area against which the entering diameter of the wire impinged. (See *a* in E and F.) At b_1 and b_2 in D will be seen a large number of striations extending in the direction of draft of the wire. These surface striations are oriented in a plane at right angles with respect to orientation of finishing striations (S_1 and S_2). b_1 and b_2 are produced by drawing wire through the die. The reverse impressions of b_1 and b_2 are transferred to the surface of wire drawn through a die. The resulting imperfections produced on the surface of copper wire cold drawn by such a chilled iron die are shown in Figure 17-F, which is a portion of the surface of a piece of wire hand drawn by the writer through a chilled iron die up to *a* and then pulled out in

the opposite direction. On the surface of this wire (*b*) will be seen the die marks or reverse impressions of imperfections in die reducing wire to diameter d_1. At *c* will be observed an entirely new set of die imperfections due to irregularities in the throat and bearing surface of die which reduced wire diameter to d_2.

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IT should be pointed out that in a continuous wire drawing machine where two or more dies are successively employed in cold drawing wire, the imperfections in the throat and bearing surface of one die may under certain conditions be transmitted to and produce a similarly shaped and located imperfection or group of imperfections in the next die in the direction of draw or draft.

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IN attempting to explain this inter-die influence it was found that when gross or major imperfections exist in the first die in a series, the reverse impression of these surface irregularities are as has been shown left on the surface of wire drawn through a particular die. These major or gross imperfections on the surface of the wire produce a localized area of accelerated friction or stress in a corresponding position on the interior of the second or third die in the direction of draw. This localized area of increased stress will, with continued drawing, produce a similarly located and shaped surface imperfection in the throat or bearing surface of the next die or dies in the direction of draft. It was found that the wire surface imperfections at the point of origin differed from the other imperfections and that they were not as sharply defined as when leaving the original die making them. The highly individual characteristics produced by the last die in a series were found to be much more sharply defined and generally were much smaller than those originating in the second or third die preceding the last die in a series.

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IN Figure 8-A, A_1 and A_2 can be attributed to the last die through which the wire was drawn, whereas Z_1 and Z_2 in Figure 7-A can be considered to be in all probability the resultants of the combined effects of the last and next to the last die in the series through which this wire was drawn.

✦ ✦ ✦

IN connection with the irregular copper-steel junctions illustrated in Figure 12, control studies were undertaken for the purpose of investigating the possibility that the irregular contour of the copper steel junction constituted an individual characteristic in which progressive changes occur as we proceed along the axis of a given piece of wire of this type. In this study a number of specimens of bimetallic wire were prepared: (1) by cross-sectioning the shaft of wire at uniform intervals along its axis (as had been done in the case study—Figures 11, 12); and (2) by removing the outer copper coating by acid and electrolytic deposition of the copper sheath. The results of these examinations indicated that the shape or contour of the copper-steel junction constituted a highly individual characteristic peculiar to a particular piece of wire and also peculiar to a particular section along the axis of the shaft of a piece of wire.

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IN seeking an explanation of the source or cause of these irregularities it was found there was a considerable divergence of opinion among metallurgists and mill men as to the specific or immediate cause. It is concluded by the writer that the irregularities are due to a combination of a number of possible causes resulting from the hot rolling of the rod and the cold drawing of the wire.

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IN Figure 14-A it will be seen that at X the rod is unsupported by the rolls. This unsupported portion on opposite sides of the circumference of the rod would result in a spreading of the rod, producing a fin extending along the outer circumference of the copper rod (*f* in Fig. 17-A). As the rod is passed through subsequent reducing passes the copper fin will be folded over, thus thinning the copper sheath. This non-uniform condition will produce a variation in the working or plastic deformation of both steel and copper along the steel-copper contact of the rod or wire being produced.

✦ ✦ ✦

IF the weld between steel and copper is not complete and continuous along the rod, there is the possibility that gas pockets between steel and copper may result. This would contribute in producing a non-uniform working and shape of copper-steel junction from which the bimetallic rod is made.

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COMPARING the rate of the reduction per pass in cold drawing copperweld and copper clad wire it was found that reductions up to 30% of the entering wire diameter was common practice in the wire mills. Crane[21] has pointed out that copper in being drawn to 30% of its original diameter produces a unit stress of approximately 25,000 pounds per square inch, whereas .10 carbon steel will produce a unit stress of approximately 40,000 pounds per square inch. As might be expected, simultaneous cold working of two metals under these conditions will, unless both metals are truly homogeneous, produce a directional segregation of non-homogeneous inclusions in either metal.

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CRANE,[22] Harris,[23] and Nädai[24] have pointed to the fact that in the cold working of metals the internal stresses produced are not uniform throughout, the metal being plastically deformed by cold working. Sauveur[25] points out the fact that there exists in metals which have been cold worked certain directional banded structures or segregations within the metal being cold worked.

[21]Crane, E. V., Plastic Working of Metals and Power Press Operations (1932) 127.

[22]Op. cit. supra note 21 at p. 149.

[23]Harris, F. W., "Distribution of Tensile Strength in Drawn Wire," Am. Inst. Mechanical Engs. for Feb., 1928.

[24]Nadai, A., Plasticity (1931) 269.

[25]Sauveur, A., The Metallography and Heat Treatment of Iron and Steel (4th ed., 1935) 186-188.

(Please turn to Page 746)

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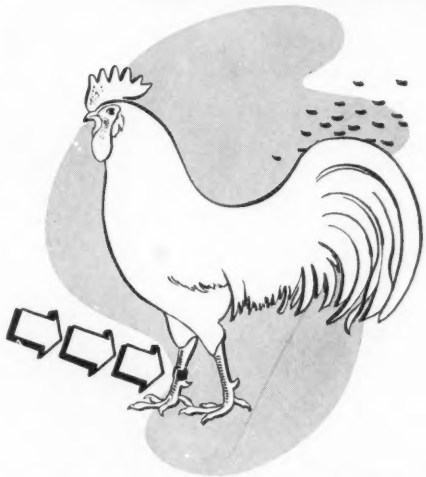

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WORCESTER, MASSACHUSETTS, U.S.A.

The Townsend Company Installs New Wire Annealing Department

A description of this unique installation of bell-type, gas-fired furnaces of interest to all annealing wire is given herewith.

THE Townsend Company of New Brighton, Pennsylvania, one of the oldest manufacturers of wire and wire product materials have just completed a unique installation for annealing wire and rod coils.

✦ ✦ ✦

FIGURE #1 shows a complete view of the entire installation, which consists of a radiant tube fired bell type furnace with four bases and a wire loading and stripping machine for placing the coils on or taking them off the spiders preparatory to loading or after discharging from the furnace.

✦ ✦ ✦

THE entire installation is extremely well planned from a handling standpoint, as an overhead crane is in position to handle the furnace, inner covers, and spiders, with or without their charges. The same crane brings the raw coils to the loading platform, or buggies, and removes them after annealing.

✦ ✦ ✦

SINCE the loading machine required a clearance below the normal landing floor, this platform was raised above the flood level to avoid a pit construction, which, in the case of this plant, would place the bases below floor level. The bases, therefore, were placed on the normal floor level and the loading platform was raised to a convenient point for placing the coils on the spiders or removing them.

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FIGURE #2 is a photograph of the installation taken at normal floor level, which shows the method of supporting bases and also shows the wire stripping machine with a spider partially loaded.

✦ ✦ ✦

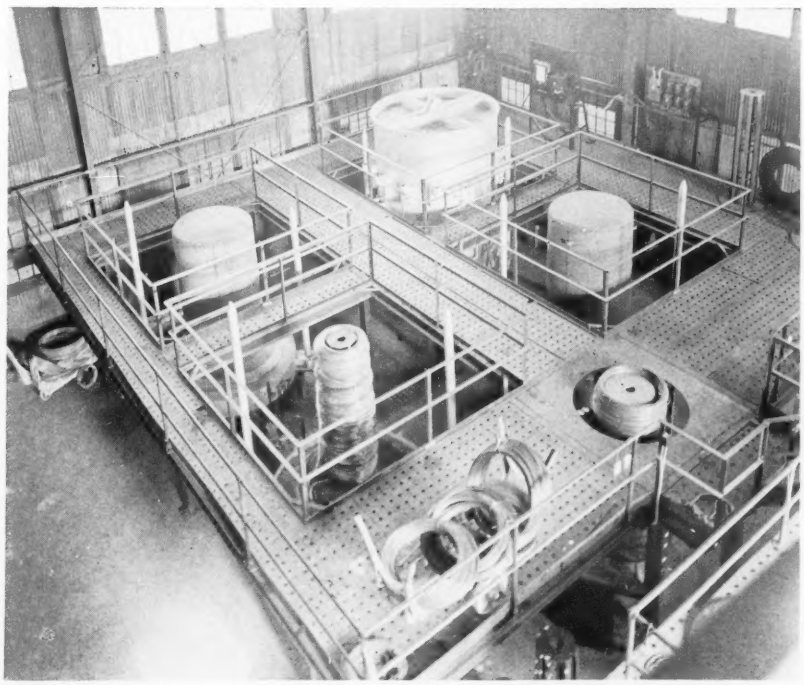

Figure 1. Complete view of entire installation.

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IT is to be noted that the bases are placed in such a position that adequate ventilation is insured for the fan cooled motors which drive the re-circulating fans in each of the bases.

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THIS installation was designed and constructed by the Lee Wilson Engineering Company of Cleveland, Ohio, in conjunction with the operating executives of the Townsend Company. The furnace is one of the Lee Wilson Engineering Company Vertical Radiant Tube Fired Cylindrical Bell Type Furnaces fired with fourteen radiant tubes in the circumference. Light weight insulation and refractories were used in the construction of the furnace to keep its weight at a minimum and still provide durability of construction and high insulating value.

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WITH this furnace are four bases, each using a re-circulating fan which drives the gases underneath the cover up through the charge and pulls them down along the face of the inner cover to reheat them. 25-12 alloy inner covers were provided.

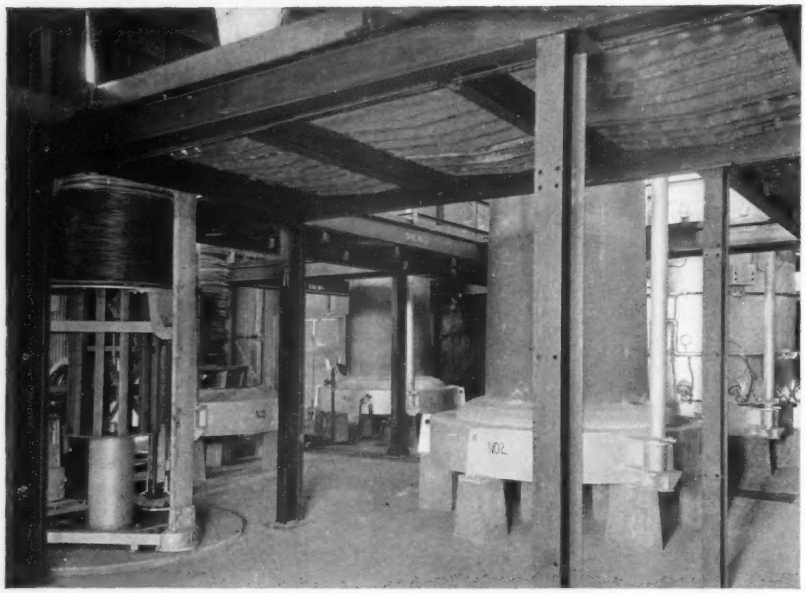

Figure 2. Showing method of supporting bases and wire stripping machine.

✦ ✦

THE furnace is fired with high pressure natural gas inspirating type burners. In this installation no deoxidizing gas equipment was provided as the entire unit is considered in the light of process treatment.

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THE wire loading and stripping device is a unique type of elevator which raises and lowers a plate, which carries the wire charge, either placing or removing the coils as the plate is lowered or raised. Since the spider is stationary and the plate moves, the coils are always loaded at the same level and removed at the same level. This machine eliminates the normal type of loading, which was to drop the coil, and the older type of discharge was to upset the spider and dump the coils on the floor.

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Figure 13. Charge placed on a base in furnace.

✦ ✦ ✦ ✦ ✦

THIS machine is a development of a well-known wire manufacturing company who had it constructed for use in their own plant. The unit now is sold exclusively by the Lee Wilson Engineering Company as part of their annealing installation.

✦ ✦ ✦

COMPLETE temperature control is provided with this equipment so that the temperature of the actual charge is the governing factor in the annealing process but a safety limit is provided so that excessive temperature can not develop in the firing tube in case of any failure in part of the control equipment.

✦ ✦ ✦

FIGURE #3 shows a charge placed on a base in the furnace with the flexible thermocouples in position. With the thermocouples at the top and the bottom of the charge, evidence of complete uniformity can be had before the furnace is removed from the charge.

✦ ✦ ✦

THE entire installation presents a remarkably neat and workmanlike appearance which speaks well of the care with which it was designed and planned.

N-O-T-I-C-E

To all readers, members and subscribers, the date of the Annual Wire Association Convention for 1939 has been changed from October 16th to that of October 23rd to 27th inclusive. Please note this change in making your plans to attend.

Wire Association Questions and Answers

Question 4228

Fine Wire Breakage in Bright Annealing

To the Wire Association:

"We are using an electrically heated furnace for bright annealing copper wire in our plant. An inert gas obtained from the combustion of illuminating gas, scrubbed and purfied is used in the chamber containing the copper wire.

Occasionally trouble is encountered in redrawing into fine wire due to breakage. This breakage is not necessarily confined to individual spools or reels but does happen altogether too frequently.

Can you offer any solution for this difficulty or give us any reason why we should encounter this breakage? May this trouble be due to the copper, or the inert gas used in the annealing chamber?

Any suggestions you have to offer on this difficulty will certainly be appreciated."

✦ ✦ ✦

Answer No. 1

"I DON'T believe the breakage these people are having is due in any way to the annealing or to the gas used in it. I would recommend that they save all breaks that occur in drawing fine wire and have these breaks examined under a microscope.

There are usually two types of breaks in fine wire, either a cup and cone type of break, which is usually caused by an improper die somewhere in the preceding drawing operation, or the most usual type which is, at least in accordance with our experience, caused by some foreign inclusion in the copper itself. This may be oxide or metallic inclusions.

I believe if they will examine the breaks that they are getting under a microscope they will be able to determine the cause of them."

✦ ✦ ✦

Answer No. 2

"IT appears to us that the gentleman asking for the information is using too rich a mixture in the inert atmosphere of the furnace and that he is having trouble with the so-called hydrogen embrittlement. We feel that the percentage of carbon monoxide must be too high. An Orsat Test would reveal the actual condition existing.

A commercially satisfactory atmosphere for bright annealing copper would be an atmosphere of 9.5% to 10% of CO_2 and preferably from .8% to 1.5% of CO."

✦ ✦ ✦

Answer No. 3

"IN reply to your inquiry it would not be possible to advise the cause of breakage in redrawing of bright annealed copper without examining samples of the broken wire. The circumstances of the case, however, suggest that breakage is probably due to embrittlement of the copper by a reducing gas in the furnace atmosphere.

In any controlled atmosphere produced by the combustion of illuminating gas there will be varying amounts of carbon monoxide and hydrogen, depending on the degree of combustion of the gas. If an oxygen bearing copper such as tough pitch, or an oxygen free copper which has previously been heated in air, is annealed in such an atmosphere embrittlement may result. Embrittlement of copper is the result of reaction between oxygen, which is present in the copper as oxide of copper, and a reducing gas. The gases, carbon monoxide and hydrogen, diffuse through the copper to reach the particles of oxide much more rapidly than the products of the reaction—carbon dioxide and steam—are able to dissipate themselves through the metal. Consequently pressure of the gas in the metal rises to the point where the metal structure is literally exploded. The cohesion of the crystallites is destroyed and the metal breaks in subsequent cold working.

To avoid embrittlement, copper known or suspected to contain oxygen should not be annealed in an atmosphere where carbon monoxide, hydrogen or unoxidized hydrocarbons may be present in amounts exceeding recommended practice."

The Wire Association is for the specific purpose of improving production methods. It was organized as a clearing house of ideas on technical problems and research work in all phases of practical wire drawing and wire working.

The inquiries discussed were received from and answered by members of the Wire Association. These inquiries are sent to the Secretary of the Association who acts as a central clearing point, and neither the names of the firms or individuals sending in the inquiry, or of the men or firms replying are divulged without permission.

✦ ✦ ✦

Answer No. 4

"YOUR correspondent in substance, asks why copper wire breaks when drawing. It is impossible to answer this question as it might be any one of many things causing the trouble.

It is my personal opinion that the difficulty does not lie in the use of combusted illuminating gas as an annealing atmosphere. If the gas used to give a non-oxidizing atmosphere were a gas rich in hydro-carbon, embrittlement of the copper might result, but obviously this is not the case.

Other reasons for breakage are, of course, improperly shaped dies, wrong size die, improper drawing lubricants, excessive friction on drawing capstans, etc."

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Answer No. 5

"IN reply to your letter regarding the question of one of your members concerning breakage encountered in redrawing fine wire, apparently from the way the question is worded, the member in question is under the impression that the breakage may be due to the annealing. The writer doubts this very much.

Whenever we have encountered trouble of this type it has invariably been one of the following three reasons:

Improper solution
Improper dies
Defects in the copper itself

In the majority of cases it is one of the first two reasons given. If the member in question will first check into his procedure, as to dies, shapes and maintenance of same, if this does not eliminate the trouble, then look into the condition, type and quality of the drawing solution, the writer believes he will find the answer to his trouble."

✦ ✦ ✦

Answer No. 6

"THE information given is far from complete enough to enable anyone to draw any definite conclusions. There are, however, a number of possibilities.

First, it is quite possible that the breakage is due to some inherent defect in the copper itself.

Second, the general run of inert gases contains hydrogen, which may be in sufficient quantities to cause 'hydrogen embrittlement', which results in breakage on further drawing of the wire.

There, of course, are numerous other possibilities regarding the cause of this breakage, which could only be determined by a detailed study of the complete process of manufacture prior to and including the drawing.

If more information than obtained by this inquiry is required by the member in question, we will be glad to receive more detailed information regarding the conditions in order that we can comprehensively study and analyze his problem."

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Answer No. 7

"IN furtherance to your letter regarding breakage of Fine Wire, the best suggestion we have on this is too tight winding on the bare wire."

✦ ✦ ✦

Answer No. 8

"TROUBLE in all probability, not due to annealer unless copper is being subjected to too much heat. Breakage can be due to three causes, namely:

1. Most probable cause is that of improper drawing of the copper on the heavy rod machines. Internal fractures in wire due to improperly shaped dies. These fractures result in breakage when any further reduction in gauge is attempted. This problem is explained in detail in an article entitled "Causes of Defects in Copper Wire" printed in the Iron Age issue of March 13, 1930.

2. Second cause, but less probable, is that due to inclusion of impurities, notably iron or steel in the copper rods. This occurs when rods are rolled on metal floors. The hot rods pick up bits of iron or steel from the floor and they are roll-

(Please turn to Page 747)

Exports and Imports of Wire

Exports of Iron and Steel Wire Products in Sept. 1938 and Sept. 1937
(In Gross Tons)

	SEPT. 1938	AUG. 1938	SEPT. 1937
Wire rods	508	357	7,571
Strip steel	5,619	4,871	10,811
Plain, black or galvanized iron or steel wire	5,073	2,383	3,091
Barbed wire and woven wire fencing	4,923	3,259	2,563
Woven wire screen cloth	96	106	80
Wire rope	218	284	694
Insulated iron or steel wire and cable—see analysis below			
Other wire and manufactures	460	363	673
Wire nails	1,974	1,654	968
Tacks	47	13	35
Other nails, including staples	414	325	288
Bolts, machine screws, nuts, rivets and washers	625	565	1,065
Total, these 11 classifications	19,957	14,180	27,839

Imports of Iron and Steel Wire Into the United States
(In Gross Tons)

Concrete Reinforcement bars	105	248	149
Hollow bar and drill steel	72	56	105
Wire rods	564	220	1,658
Barbed wire	671	1,068	1,624
Round iron and steel wire	167	118	345
Telephone and telegraph wire	1	1	.....
Flat wire and strip steel	180	154	371
Wire rope and strand	214	156	320
Other wire	49	96	146
Hoops and bands	922	908	932
Nails, tacks and staples	739	831	321
Bolts, nuts and rivets	62	1	10
Total, these 12 classifications	3,746	3,857	5,981

Exports of Insulated Wire and Cable, September, 1938

	Foreign		To U. S. Possessions	
	Pounds	Dollars	Pounds	Dollars
Rubber covered wire	429,348	$ 99,227	122,011	$22,884
Weatherproof wire	266,018	39,267	69,862	11,842
Other insulated copper wire	374,671	72,213	138,764	20,493
Nickel-chrome electric resistance wire	18,847	22,581	.....	.....
Total, these 4 classifications	1,088,884	$233,288	330,637	$55,219

PIG iron foreign shipments in September moved up sharply to 66,600 tons and compared with 19,756 tons in August and 64,945 tons in September 1937. The principal markets were Japan, 59,833 tons, and Germany, 5,000 tons. Black steel sheet shipments totaled 16,610 tons against 11,949 tons and 28,166 tons and the bulk was taken by the United Kingdom, 5,876 tons; Canada, 3,142 tons; Mexico, 1,452 tons; Brazil 928 tons, and the Netherlands 897 tons.

✦ ✦ ✦

EXPORTS of rails amounted to 13,817 tons against 12,655 tons and 9,704 tons and, for the most part, went to Hong Kong, 9,500 tons, and Brazil, 3,179 tons. Tin plate shipments (in a widespread trade) totaled 12,061 tons against 9,163 tons and 20,815 tons, and went to the Soviet Union, 4,728 tons; Canada, 1,154 tons; Mexico, 900 tons; the Netherlands, 711 tons, and Cuba, 538 tons.

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PLATE export shipments (also going to numerous markets) totaled 10,752 tons against 13,150 tons and 44,535 tons, and the outstanding markets were the Netherlands, 1,845 tons; Canada, 829 tons; Brazil, 531 tons; and Egypt, 477 tons). Next ranking were steel bars with 9,802 tons against 11,838 tons and 12,190 tons, taken principally by the Philippine Islands, 2,535 tons; Japan, 1,754 tons; Canada, 1,361 tons; and Cuba, 879 tons.

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EXPORTS of scrap in September totaled 149,673 tons valued at $2,093,925 in comparison with 108,029 tons valued at $1,478,545 in August and 256,191 tons valued at $4,815,993 in September 1937. Shipments in the first nine months of the year amounted to 2,182,438 tons valued at $33,856,001 against 3,331,890 tons valued at $65,965,436 last year.

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JAPAN imported 68,354 tons of iron and steel products (excluding scrap) from the United States in September, thereby continuing to be the outstanding market in this trade. The principal products shipped to this destination were pig iron (59,833 tons); steel ingots (4,705 tons); and steel bars (1,754 tons). Canada followed with 18,447 tons and the leading items were black steel sheets (2,248 tons); strip steel (2,205 tons); steel bars (1,361 tons); and tin plate (1,154 tons). Hong Kong ranked next with 11,022 tons of mostly rails (9,500 tons). Brazil took 10,477 tons of chiefly rails (3,179 tons); wire (2,831 tons); black steel sheets (928 tons); and galvanized steel sheets (730 tons). Fifth-ranking, the Philippine Islands accounted for 9,815 tons of mainly steel bars (2,535 tons); galvanized steel sheets (1,872 tons); and cast-iron pressure pipe and fittings (1,275 tons). The Soviet Union took 6,982 tons, and in this trade the ranking product was tin plate (4,728 tons).

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THE United States import trade in iron and steel products (excluding scrap) totaled 23,740 gross tons valued at $1,332,092 in comparison with 18,404 tons valued at $1,182,741 in August and 28,505 tons valued at $1,908,645 in September last year.

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PIG iron imports in September amounted to 6,922 tons against 961 tons in the preceding month and 7,911 tons in the corresponding month of last year, and accounted for the highest tonnage for any individual product within the iron and steel group during the month. The outstanding source of supply was the Netherlands which furnished 6,820 tons in the aggregate. Ferromanganese and spiegeleisen receipts totaled 4,956 tons against 2,630 tons and 4,898 tons and came mostly from the Nether-

lands (1,579 tons); Norway (1,411 tons; and Canada (1,062 tons).

✦ ✦ ✦

THE third ranking product in the month's trade was steel pipe whose aggregate of 2,339 tons compared with 2,688 tons and 1,930 tons and chiefly came from Germany (978 tons); Czechoslovakia (514 tons); France (361 tons); and Switzerland (245 tons). Then came shapes with 1,902 tons against 2,335 tons and 2,537 tons, and the outstanding sources were Belgium (1,716 tons); and France (112 tons). Hoops and bands followed with 1,790 tons against 3,534 tons and 932 tons, and were taken principally from Belgium (1,232 tons); and France (363 tons). Steel bar receipts amounted to 1,230 tons against 1,794 tons and 1,863 tons and in this trade the leading countries of supply were Belgium (716 tons); Sweden (205 tons); Germany (144 tons); and France (140 tons).

FOR the first time in a number of months, Belgium in September was supplanted as the leading import source when the Netherlands sent in 8,420 tons of chiefly pig iron (6,820 tons); and ferromanganese (1,579 tons). Belgium followed with 5,134 tons of chiefly shapes (1,716 tons); hoops and bands (1,232 tons); steel bars (716 tons); rails and track material (437 tons); and barbed wire (428 tons). Germany ranked next with 2,921 tons of principally steel pipe (978 tons); nails, tacks, and staples (404 tons); hoops and bands (363 tons); barbed wire (233 tons); and rails and track material (214 tons). Next-ranking was Sweden with 1,458 tons, and in this trade the outstanding items were wire rods (502 tons) steel pipe (245 tons); and steel bars (205 tons). Then came Norway with 1,412 tons, of which the bulk was ferromanganese (1,411 tons). Sixth-ranking, France accounted for 1,281 tons of mostly hoops and bands (363 tons); steel pipe (361 tons); steel bars (144 tons); and shapes (112 tons).

✦ ✦ ✦

IMPORTS of scrap iron and steel during September totaled 4,218 tons valued at $43,449 in comparison with 1,637 tons valued at $26,558 in August and 8,566 tons valued at $130,501 in September 1937. Canada accounted for the entire September trade. In the initial 9-month period of 1938, the scrap aggregate was 7,659 tons valued at $95,339 against 70,257 tons valued at $975,546 in the corresponding months of 1937, and in this trade Canada was by far the principal supplier.

✦ ✦ ✦

EXPORTS of iron and steel wood screws during September, 1938 totaled 9,024 gross valued at $1,643. Of this total Mexico took 2,068 gross valued at $256; Canada 1,495 gross valued at $223; Venezuela 1,300 gross valued at $135;

(*Please turn to Page 736*)

MICROMETER PRECISION — MICRO-WELD — ELECTRIC WELDING

A complete portable unit machine for general purpose Butt Welding, instantly adjustable for various sizes of wire and perfectly adaptable for all wire manufacturing and fabricating requirements.

✦ ✦ ✦

THIS Welder is provided with a specially designed, sensitive limit switch, operating automatically with consistently uniform results on even the smallest sizes of wire, where reduced upset spring pressure is necessary. Tungsten contact tips are used in this switch to eliminate the maintenance and adjustment ordinarily required on copper contacts, which are customarily used for this service. By using the best material available in this equipment, positive, accurate results are secured under all conditions.

✦ ✦ ✦

Your inquries are solicited.

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MICRO-WELD BUTT WELDER

Model E weighs only 50 pounds and is so simply designed that anyone can weld wires from No. 4 to No. 20 gauge with it—instantly changing from one gauge to another.

EVERY working part of the machine is enclosed and protected from dirt and corrosion from acid fumes. The only servicing that is necessary, is an occasional brushing of the dies with the wire brush which comes with the machine, and an occasional oiling with Three-In-One oil in the four oil holes which are visible on the index barrel and slides.

✦ ✦ ✦

HIGH electrical efficiency, with only 2½ KW rating at full capacity, allows light socket operation, which further increases the general utility of this adaptable Welder.

✦ ✦ ✦

FOR especially rugged service or for traveling crane mounting, this machine is also available made from high strength bronze, at no additional increase in price.

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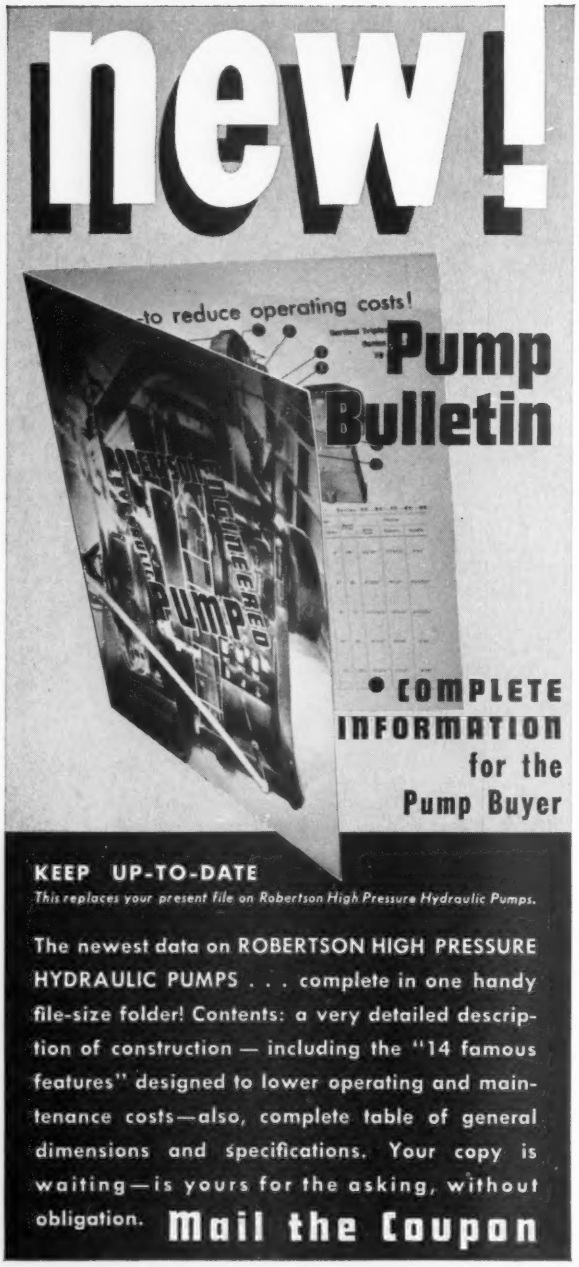

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Exports and Imports

(*Continued from Page 735*)

Panama 1,063 gross valued at $193; Dominican Republic 650 gross valued at $112; Costa Rica 595 gross valued at $91.

✦ ✦ ✦

EXPORTS of brass wood screws during the same month totaled 2,509 gross valued at $1,228. Of this total Cuba took 1,009 gross valued at $492; Mexico 482 gross valued at $225; Canada 297 gross valued at $150; Netherland West Indies 160 gross valued at $109; Guatemala 102 gross valued at $40.

✦ ✦ ✦

IMPORTS of wood screws during the same month totaled 4,740 gross valued at $364. Of this total Belgium supplied 4,150 gross valued at $2,541 and Sweden 590 gross valued at $110.

✦ ✦ ✦

CARD CLOTHING receipts totaled 11,799 square feet valued at $18,947 against 11,276 square feet valued at $19,497, and came from the United Kingdom (10,992 square feet valued at $17,419) and Belgium (712 square feet valued at $1,332.

✦ ✦ ✦

RECEIPTS of WIRE HEDDLES totaled nothing.

✦ ✦ ✦

A TRADE of 27,169 square feet resulted in WIRE CLOTH AND SCREEN against 35,398 square feet and came from the Netherlands 9,474 square feet; Germany 7,634 square feet; Canada 5,454 square feet, and France 4,197 square feet.

✦ ✦ ✦

FOURDRINIER AND OTHER PAPER-MAKING WIRE imports at 15,406 square feet as against 20,027 square feet, and were supplied by Germany 9,164 square feet; Sweden 3,520; and France 2,111 square feet.

✦ ✦ ✦

RECEIPTS OF WIRE FENCING AND NETTING, galvanized before weaving amounted to nothing, compared with 33,500 square feet. Of that galvanized after weaving, the total was 295,200 square feet as against 2,128,650 square feet and came from Belgium 225,000 square feet and the Netherlands 70,200 square feet.

'Round the World With the Wire Industry

German Notes

THE wire machinery business continues satisfactory. Shipment dates are 7 to 10 months for domestic German buyers and 4 to 6 months for exporters. From Oversea the demand is better than from Europe, with the exception of the Balkan countries where the demand is large. German wire machinery will also participate in the barter business with South Africa by some 22,000£ while the sales to Turkey will amount to about £30,000. Mandschukuo and Japan continue to buy wire drawing machines. As the machinery equipment of the Japanese Companies is particularly scanty and obsolete, large orders may be expected from that country. Germany has a large export surplus to Japan, but an import surplus from Mandschukuo. The balance accumulated from one country is mainly used to cover the other purchases. Wire machinery is more or less neglected, while bolt, chain, rivet and screw machines sell best.

✦ ✦ ✦

THE demand for both domestic and export cable continues more satisfactory. Export turnovers of the leading cable makers were this year about 40% of the entire production. Lead covered cables are neglected. The prices are affected by lower quotations from certain American Companies.

✦ ✦ ✦

ON the wire export market the activity is fully maintained, particularly as concerns wire nails, and fencing wire. The export sales of the IWECO in August slightly exceeded 40,000 tons, were about 43,000 tons in September, in spite of the political crisis and will no doubt be up in October, which compares favourably with the lowest point of this year in June when about 27,000 tons sold for export. Prices are unaltered. There are few, if any, outsider offers in the market. American competition is still felt, although less than in July and August.

(*Please turn to Page 738*)

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'Round the World With the Wire Industry

(*Continued from Page 737*)

STANDARDIZATION of wire mesh will for the present not be continued. The existing standards will be left unchanged and no new ones issued.

✦ ✦ ✦

THE circumstance of Poland's having cancelled the agreement with the IWECO has not yet affected the market. Exporters have tried in the weeks after the Polish withdrawal to buy in Poland cheaper than prices quoted by the IWECO, but almost without result. Only in the Scandinavian markets some sizes of wire nails were offered at cheaper prices, but nowhere else.

✦ ✦ ✦

CHINA is buying fencing and barbed wire (the latter through Hongkong and Tientsin) and business is not unsatisfactory, except for wire rods in short lengths (up to 30') for which the demand is very small as the bulk of these products is regularly shipped to the Interior.

✦ ✦ ✦

THE wire rod market is satisfactory. The German production was 125,400 tons in August and 123,227 tons in September. The price of £ (gold 5. 2. 6 to 5. 5. 0 is easily maintained. The German industry is selling at present about 4-6000 tons wire rods only for export and imports about 1200-1500 tons. The demand for S.M. wire rods which for a certain time had been rather patchy, has also improved.

✦ ✦ ✦

German Wire Rope in First Half of 1938

THE American Consulate at Cologne writes that the operations of **German** wire rope manufacturers were not adversely influenced by seasonal factors this year. On the contrary, the heavy domestic demand has thus far had the effect of keeping production of a very high level. Exports, however, are suffering from the international situation. Germany's exports of steel wire rope and wire strand during the first half of the current year at 8,029 metric tons, compared with 9,658 tons last year.

✦ ✦ ✦

International Wire Agreement

IT is reported in France that the International Agreement of Wire Manufacturers has practically been concluded to the satisfaction of all parties, advises the office of the American Commercial Attache, Paris. It is understood that the so-called I.W.E.C.O. (International Wire Export Corporation) has accomplished the renewal of the understanding with the French producers in entire agreement as regards the quota which has been allotted.

✦ ✦ ✦

James Day (Machinery) Ltd. Organized

ANNOUNCEMENT is made of the organization of the above company, with headquarters and offices at Sentinel House, Southampton Road, London, W. C. 1, England. Mr. James Day, the head of the company, after spend-

FARREL NI-HARD
The Roll for High Finish Sheets

Present-day demand for highly finished rolled strip and sheet, with competitive conditions compelling heavier passes to reduce rolling costs, requires rolls which combine extreme hardness with high strength and flawless surface.

Farrel Ni-Hard Rolls have been developed to meet these conditions. They have a hardness of 80 to 90 scleroscope and are completely free from pinholes or "orange-peel" surface; they therefore produce sheets with a higher quality finish and greater uniformity of finish than can be obtained with chilled or other types of alloy rolls.

Their high strength and hardness offer protection against both breakage and deterioration of roll surfaces and permit heavier passes. Less scouring and grinding than any other type of cast roll, and a longer useful life, provide a definite economy both in maintenance and roll cost per unit of output.

Details of application to individual conditions and probable performance will be furnished on request.

Farrel-Birmingham Rolling Mill Equipment includes: Rolls — Rolling Mills — Rod Mill Tables and Manipulating Equipment — Universal Mill Spindles — Rod Coilers — Lead Presses for Pipe or Rod — Roll Grinding Machines — Roll Calipers — Gears — Mill Pinions — Pinion Stands — Drives up to 10,000 H.P. — Flexible Couplings.

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Company, Inc.
38 Main St., Ansonia, Conn.

ing some time as Engineer in the Cable Works of Messrs. Connolly Brothers of Manchester, joined the Selson Machine Tool Company, Ltd., of London as Sales Engineer, and since 1919 has been representing for that company various American companies in the sale of their equipment throughout Europe.

✦ ✦ ✦

IN the August, 1938, issue of WIRE & WIRE PRODUCTS, Mr. Day presented an interesting article on the subject of "Selling American Machinery in Europe."

✦ ✦ ✦

MR. DAY has just returned to England after spending about two months in the United States, and will represent in Great Britain and on the Continent the following American companies:

John Royle & Son, Paterson, New Jersey, manufacturers of extruding machinery and hose-weaving looms.

The American Insulating Machinery Company of Philadelphia, Pennsylvania, manufacturers of enamelling, insulating, spooling, armoring, and wire drawing machines, together with a general line of special machinery for the insulated wire and cable industry.

The Mossberg Pressed Steel Corporation of Attleboro, Massachusetts, manufacturers of pressed metal reels, spools, drop wires, high-speed braider carriers, etc.

The New England Butt Company of Providence, Rhode Island, manufacturers of braiding, stranding, measuring, cabling machinery for the non-ferrous and insulated electric wire industry. Our best wishes go to Mr. Day for success in his new enterprise.

Manufacturers of materials, tools and equipment for wire drawing and forming plants are constantly making improvements and additions to their lines. If you do not find the product or service in which you are interested, additional information will be supplied promptly. Simply address:

WIRE & WIRE PRODUCTS
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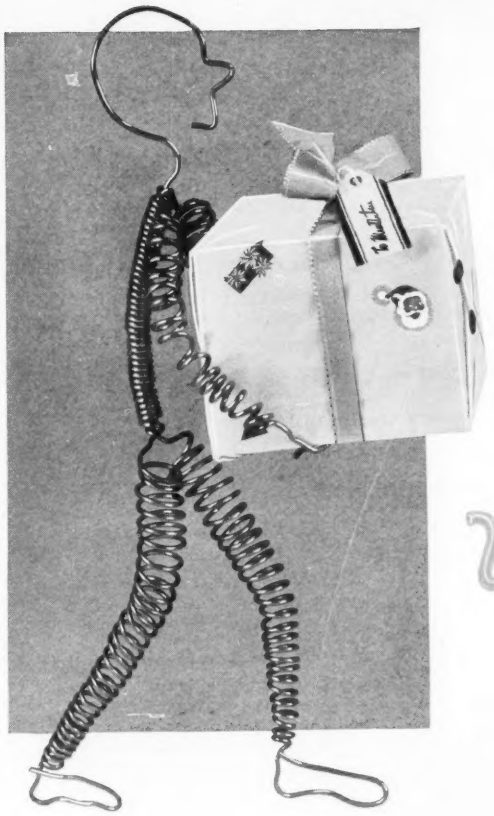

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KEYSTONE STEEL & WIRE CO. PEORIA, ILL.

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Coppered
Annealed
Galvanized

A Review of Recent Wire Patents

No. 2,131,766, METHOD OF PRODUCING COUPLINGS, Patented October 4, 1938 by Robert Temple, Jr., Pittsburgh, Pa., assignor to Robert Temple, Inc., Denver, Colo.

A sudden blow created by the detonation of an explosive charge compresses a sleeve about a pair of wire ends to be coupled and at the same time offsets the longitudinal axes of at least part of the wire ends within the sleeve.

✦ ✦ ✦

No. 2,132,235, INSULATED ELECTRIC CONDUCTOR, Patented October 4, 1938 by Richard Duane Greene, Trenton, N. J., assignor to John A. Roebling's Sons Company, Trenton, N. J., a corporation of N. J.

A plurality of copper wires and steel wires are stranded together, each of the wires being tin coated and integral with one another at their places of contact, the united stranded wires being sheathed with an insulating coating of vulcanized rubber.

✦ ✦ ✦

No. 2,132,252, WOVEN WIRE BELT FOR PAPER MAKING MACHINES, Patented October 4, 1938 by Louis Nicholas Weber, Appleton, Wis., assignor to Appleton Wire Works, Inc., Appleton, Wis., a corporation of Wisconsin.

Flat cross-section warp wires are combined with tubular weft wires, of circular cross-section before weaving,

Complete Descriptions and Drawings of Patents May Be Had for 25 cents. Address, Wire & Wire Products, 17 East 42nd St., New York.

and which are deformed by the warp wires to produce a crimped structure wherein the crimp is deeper than has been possible with solid cross-section weft wires.

✦ ✦ ✦

No. 2,132,269, CABLE ANCHOR, Patented October 4, 1938 by Frederick J. McHugh, Dorval, Quebec, Canada.

Individual strands of cables used in the construction of suspension bridges are anchored at points equi-distant from a splay point of the cable by spheroidal disposition of the points of anchorage about the splay point whereby loads are transferred direct to masonry concentric with the pull on said strands.

✦ ✦ ✦

No. 2,132,566, CABLE WRAPPING, Patented October 11, 1938 by Guy Gilbert Greene, San Francisco, and Fred A. Pneuman, New York, N. Y.

The device includes a flyer and wire straightening rolls so mounted by the flyer that wire leaving the rolls feeds tangentially onto the cable to be wrapped.

✦ ✦ ✦

No. 2,133,408, SPRING UNIT, Patented October 18, 1938 by Sheridan A. Walker, Newburgh, N. Y., assignor to Walker Spring Co., Inc., Newburgh, N. Y., a corporation of New York.

Extending lengthwise of a spring unit above and below the springs are steel bands so placed that adjacent springs overlap the bands and are secured thereto by means which anchors each two lateral adjacent springs firmly to one another and to the strip which mutually overlies or underlies them.

✦ ✦ ✦

No. 2,133,550, METHOD OF FORMING A WIRE STRUCTURE, Patented October 18, 1938 by Earl W. Little, Indianapolis, Ind.

In the construction of bird cage crown portions, the hooked wire ends are secured in radiating relation to an anchor ring by a stamping operation which locks them to the ring so as to resist any dislodgment resulting from further drawing and forming operations.

✦ ✦ ✦

No. 2,133,611, WIRE SPRING FOR CUSHIONED SEATS OF VEHICLES, Patented October 18, 1938 by Morris Freund, Cleveland, Ohio, assignor, by direct and mesne assignments, of one-half to Jacob Kronheim, Shaker Heights, Ohio, and one-half to John C. Lincoln, Scottsdale, Arizona.

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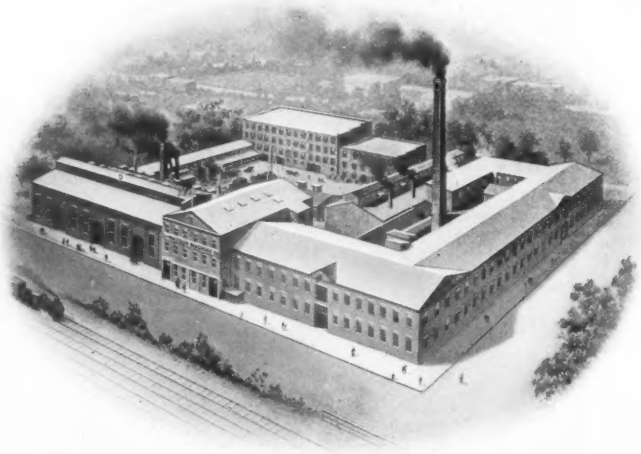

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MANUFACTURERS OF

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A plurality of flat sinuous springs are secured each at its forward end to the forward end of a frame structure by a downwardly and rearwardly extending portion and at its rearward end to the back of the frame structure by a rearwardly and downwardly curved portion in a manner to permit of each spring being interchanged.

✦ ✦ ✦

No. 2,133,863, ELECTRIC CABLE, Patented October 18, 1938 by Homer G. Knoderer, Fairfield, Conn., assignor to General Electric Corporation, a corporation of N. Y.

Wound around the conductor with a short pitch spiral is a strand surrounded by a thin elastic insulating covering that may be severed upon pulling the strand back longitudinally of the cable.

✦ ✦ ✦

Reissue No. 20,897, MULTISTRAND SPIRAL FABRIC, Patented October 25, 1938 by Clarence E. Pink, Cambridge, Md.

A plurality of spiral strands are threaded one into another with cross rods inserted through the convolutions of the strands in contact with the inner peripheries thereof and secured to the extremities of the strands, the convolutions being interlooped with adjacent convolutions and extending around the cross rods.

✦ ✦ ✦

No. 2,134,293, WOVEN WIRE FABRIC FOR DANDY ROLLS, CYLINDER MOLDS, OR THE LIKE, FOR PAPER MAKING MACHINES, Patented October 25, 1938 by Nelson W. Webb, Belleville, N. J., assignor to Eastwood-Neally Corporation, Belleville, N. J., a corporation of N. J.

Seam forming wires constituting warp wires are woven into the fabric in predetermined space relation as determined by standardized circumference of cylinder each comprising a wire similar to the other warp wires together with solder contiguous to and simultaneously woven with the seam forming wire.

✦ ✦ ✦

No. 2,134,371, SPRING ASSEMBLY FOR UPHOLSTERY, Patented October 25, 1938 by Fred A. Nachman, Jr., Chicago, Ill., assignor to Nachman Spring-Filled Corporation, Chicago, Ill., a corporation of Ill.

Disposed over the end coils of contiguous rows of upholstery springs confined in fabric cells is a plurality of resilient flat members of wire bent to sinuous or zig-zag form and varying in width at different points in their lengths, the resilient flat members being fastened by means extending through the fabric casings and around the coils of two of the springs.

✦ ✦ ✦

John R. McKean

IT is with much sorrow and regret that we announce the death of Mr. John R. McKean, assistant manager and superintendent of Kennecott Wire & Cable Co., Phillipsdale, R. I., at his home in Rumford, Rhode Island, September 18th, 1938, aged 47 years.

✦ ✦ ✦

Wickwire Spencer Steel To Move Goddard Works To Buffalo Next Spring

REMOVAL of the Goddard Works of Wickwire Spencer Steel Company to a new plant under construction in Buffalo will begin "early next Spring," according to a company executive. The Morgan Spring Works of the company in Greendale will not be affected, under present plans.

✦ ✦ ✦

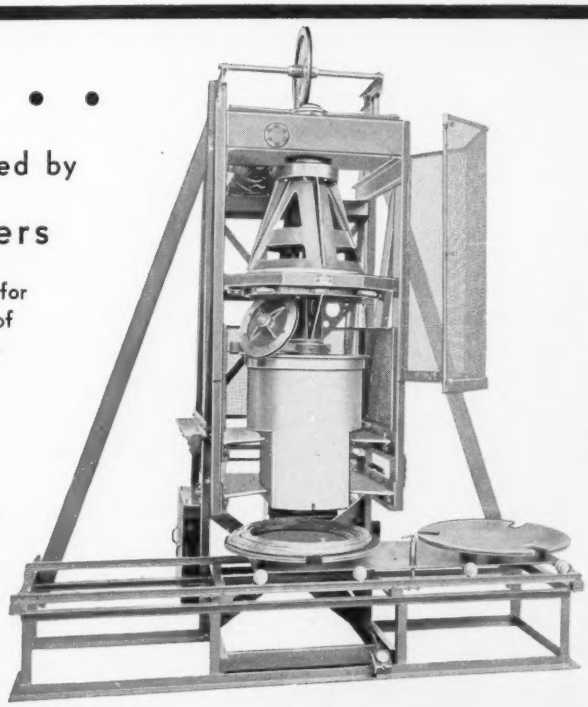
OFFICIALS explained that competition has made it essential for the company to move its wire works nearer the mid-western markets where the bulk of the company's products is sold.

The date of the Annual Wire Association Convention for 1939 has been changed from October 16th to that of October 23rd to 27th inclusive. Please note this change in making your plans to attend.

Stops for removing filled coils are eliminated by

Syncro *Continuous* Coilers

The Syncro continuous coiler eliminates the necessity for shutting down wire drawing machines for the removal of filled coils. Coil weights are predetermined. On large wire especially, the shut down periods for this purpose are equal to or longer than the actual drawing time. With the Syncro continuous coiler operating in conjunction with a wire drawing block, the filled coils can be removed without interrupting the wire drawing process, which greatly increases output and efficiency. Write for bulletin No. 700.



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Outstanding Personalities of the Wire Industry

J. R. Townsend on ASTM Executive Committee

J. R. TOWNSEND, Materials Standards Engineer, Bell Telephone Laboratories, Inc., New York City, has been elected a member of the Executive Committee of the American Society for Testing Materials. He takes the place vacated by Mr. Allen Rogers, who has recently resigned because of ill health.

MR. Townsend has been extremely active in many fields of work of the Society. He is Chairman of Committee B-6 on Die-Cast Metals and Alloys, a member of Committee E-10 on Standards, and participates in the work of other groups, including Committee B-2 on Non-Ferrous Metals and Alloys, A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys, E-1 on Methods of Testing (Chairman of the Section on Indentation Hardness) and the Research Committee on Fatigue of Metals. A member of the New York District Committee, he was recently elected chairman of this group.

✦ ✦ ✦

HE is the author of numerous technical papers and reports. In addition to ASTM he is active in the work of the American Society for Metals, American Welding Society, American Society of Mechanical Engineers, American Ceramic Society and American Standards Association.

✦ ✦ ✦

American Steel & Wire Announces Promotions

EFFECTIVE immediately, two promotions in the sales department are announced by American Steel & Wire Co., subsidiary of U. S. Steel Corpn.

✦ ✦ ✦

H. C. PEARSON has been appointed Assistant Manager of Sales of the New England District, located in Boston, Mass. Mr. Pearson started work for the Wire Company in 1904 and since 1925 has been a salesman in the Manufacturers Department.

✦ ✦ ✦

A. M. MARSH assumes the post of Assistant Manager in the Merchant Products Department in the Chicago office. He has worked for the company as a salesman since 1934.

✦ ✦ ✦

H. A. HAMILTON will also continue as Assistant Manager in the Merchant Products Department at Chicago, a post which he has held since 1920.

✦ ✦ ✦

Aetna-Standard Expands

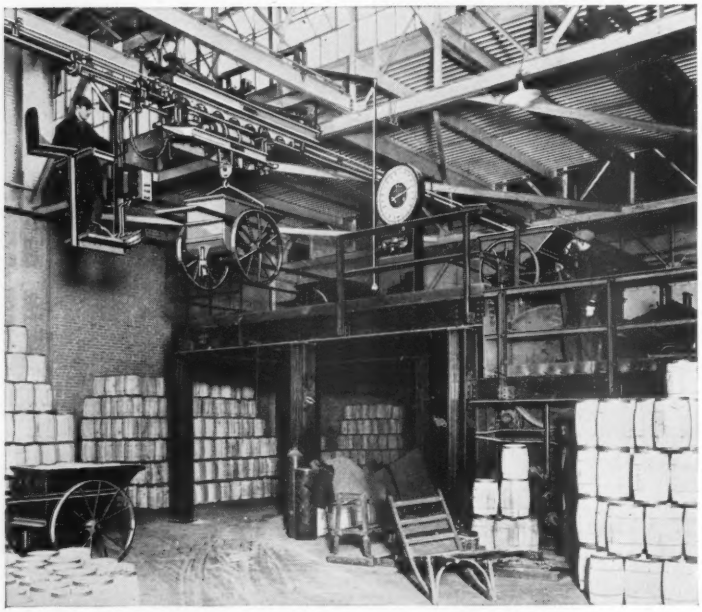
THE Aetna-Standard Engineering Company of Youngstown, Ohio has taken over The Griffiths-Bowman Engineering Company of Massillon, Ohio.

✦ ✦ ✦

FREDERICK J. GRIFFITHS and K. Bert Bowman, President and Vice President, respectively, of The Griffiths-Bowman Company, are internationally know metallurgists. They have specialized in the making of alloy steels and are recognized in this country as leaders in this rapidly developing field. Their experience and

CLEVELAND TRAMRAIL

MATERIALS HANDLING EQUIPMENT



• In this nail mill, buggy loads of product are picked up at the machines by the operator, who rides on the platform controlled motor operated carrier, he weighs and unloads on the mezzanine floor for dumping into the tumbler. The overhead track scale with a load thereon is shown in the upper left of the photo.

Consult your phone directory under Cleveland Tramrail.

CLEVELAND TRAMRAIL
Division of
THE CLEVELAND CRANE & ENGINEERING CO.
1141 Depot St.
WICKLIFFE, OHIO

ability supplement and complete the engineering organization of Aetna-Standard Company, which has specialized in mechanical equipment for the steel industry.

✦ ✦ ✦

Perkin Medal Award

DR. WALTER S. LANDIS has been elected to receive the Perkin Medal of the Society of Chemical Industry for 1939. The medal is awarded annually for valuable work in applied chemistry and will be presented this year to Dr. Landis for his work on cyanamid, derivatives of cyanamid, fertilizers, ammonium phosphate in particular, the first commercial production of argon and contributions to the explosive industry. The selection is made by a committee representing the five chemical societies in the United States.

✦ ✦ ✦

THE medal will be presented on January 6, 1939 at a meeting to be held at The Chemists' Club, 52 East 41st Street, New York City. Details will be announced later.

deWitt H. Gunsolus

THE Continental Roll and Steel Foundry Company announces the appointment of deWitt H. Gunsolus as representative for the Furnace Division, with offices in Cincinnati, Ohio at 534 Vine Street. He will handle sales and engineering of industrial combustion equipment and allied furnace accessories manufactured by this division of the company.

✦ ✦ ✦

J. R. Weaver to Handle New Duties

JAMES R. WEAVER, Director of Equipment, Inspection and Test for the Westinghouse Electric & Manufacturing Company, will in addition to his present duties be responsible for equipment negotiations, according to a recent announcement of T. I. Phillips, General Works Manager.

✦ ✦ ✦

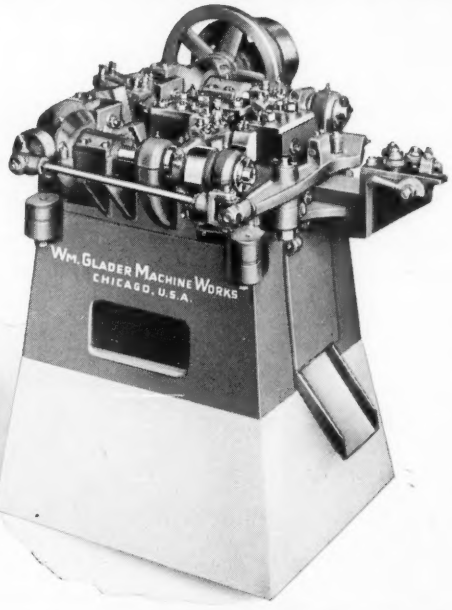
MR. WEAVER entered the employ of the Company in 1915, later serving in the capacities of assistant works mechanical engineer, assistant superintendent of equipment, superintendent of manufacturing equipment, and equipment engineer. In 1936, he was appointed Director of Equipment, Inspection and Test. In this capacity, he is responsible for the selection and development of machine tools and their applications for the Company and serves in an advisory and guiding capacity for the inspection and test personnel. In his new capacity he will be responsible for negotiating and purchasing capital account equipment, in addition to his present activities. His headquarters will remain at East Pittsburgh. He is a member of the American Society of Mechanical Engineers and the American Society of Tool Engineers.

✦ ✦ ✦

The date of the Annual Wire Association Convention for 1939 has been changed from October 16th to that of October 23rd to 27th inclusive.

700 NAILS PER MINUTE

GLADER BRAD AND FINE NAIL MAKING MACHINE



This machine will produce nails and brads ¼" to 1⅛" in length from wire 22 gauge to 16 gauge inclusive.

The Glader machine is made in eleven different sizes. This enables us to cover any size of nail most efficiently.

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For nearly all commercial acids, at all strengths and temperatures, including hot, weak sulfuric, hot muriatic, nitric, acetic, phosphoric, sulfurous and organic acids.

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For abrasion and erosion resistance.

Some of the alloys have tensile strengths up to 150,000 lbs/sq/in.

Brinell hardness ranges from 120 to 600.

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Of course, no one alloy has the maximum of **all** the essential qualities. There is, however, one alloy that will meet the most important of your requirements, with a minimum of compromise of the other desired qualities.

Ask to have a Sales Engineer call, or write direct and we shall be glad to make recommendations.

THE DURIRON COMPANY, Inc.

445 North Findlay St. Dayton, Ohio

PROCEEDINGS

OF THE WIRE ASSOCIATION MEETINGS

▲▲▲

STENOGRAPHIC minutes of the discussions at the Wire Association meetings held at Detroit, Michigan, October 17 to 21, 1938, inclusive, will be published in full in the January, 1939 issue of WIRE & WIRE PRODUCTS.

✦ ✦ ✦

MEMBERS of the Wire Association and subscribers to WIRE & WIRE PRODUCTS will receive these proceedings in this manner.

✦ ✦ ✦

OTHERS desiring the proceedings can obtain them either by becoming members of the Wire Association, or by subscribing to WIRE & WIRE PRODUCTS.

Patent for Forming Hard Compact Metals

PATENT No. 2,133,495, has been recently issued to F. H. Willey, President of Willey's Carbide Tool Company, which relates to the method of forming hard compact metals suitable for tools such as cutting, drilling, surfacing tools, drawing dies, molds and other implements required to be formed of a hard metal composition such as in the sixth group of Mendelejeff's Periodic Table together with the metal of the iron groups.

✦ ✦ ✦

A COPY of this patent will be sent to anyone who is interested in same together with additional patent copies under which Willey's Carbide Tool Company operates, namely; Patent Numbers 2,074,038, 1,702,765 and 1,702,766. For copies address Willey's Carbide Tool Co., 1342 West Vernor Highway, Detroit, Michigan.

✦ ✦ ✦

Henry E. Charles

HENRY E. CHARLES, of The Okonite Company, passed away November 7th after a short illness of a week.

✦ ✦ ✦

MR. CHARLES was Mechanical Superintendent for The Okonite Company in Passaic, the Okonite-Callender Cable Company in Paterson, and the Hazard Insulated Wire Works in Wilkes-Barre, Pa., having been with the Okonite organization since 1924.

✦ ✦ ✦

HE was born in Williamsburg, Virginia, on the campus of William & Mary College. His first work was at the Newport News Shipbuilding & Drydock Company; from there he was affiliated in turn with the Atlantic Transport Line as a Marine Engineer, the Worthington Pump, E. I. du Pont de Nemours, The Gillespie Corporation, before entering the Okonite organization. He was very well known in business and fraternal circles—was Vice-President of the Passaic County Shrine Club, a member of Salaam Temple, A. O. N. M. S., the Ivanhoe Lodge, F. and A. M., and the Paterson Rotary Club.

Flexarc Welding Cable

A FLEXARC Welding Cable, that is flexible, durable, light in weight and has positive insulation, applicable for field and shop use, is announced by Westinghouse Electric & Manufacturing Company. These cables comply in all respects with latest I.P.C.E.A. specifications for rubber sheathed arc-welding cables.

✦ ✦ ✦

THE paper separator between the copper and rubber sheathing, permits sliding action between the outside layer of wires and the rubber jacket. Also, the large number of fine copper wires composing the stranding provide for extreme flexibility. The protective jackets of these cables are of 60% rubber armor, built for hard usage under the most severe conditions and for long, reliable service with maximum safety.

✦ ✦ ✦

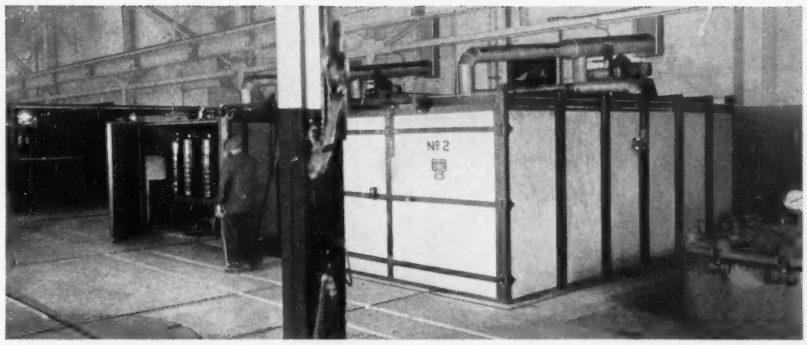
Metal Coloring and Finishing

THIS is the authorized translation of the second German edition of the above book by Hugo Krause, Consulting Chemist. This volume discusses from the theoretical, practical applications, and patent angles the subject of metal coloring by chemical, mechanical and electrical methods, the latter being sub-divided into cathodic and anodic procedures. The author attempts to relate all the important methods applied to iron and steel and the base and noble metals, in their sheet, cast, mechanically fabricated, or electroplated forms.

✦ ✦ ✦

IT is comprehensive and will be of use as a reference and guide book to those engaged in metal coloring in its decorative as well as protective phases. Many of the so-called secret processes of the electroplating art are described in considerable detail with critical comments by the author.

For Information
Regarding
The Wire Association
Address
Richard E. Brown, Secretary
17 E. 42nd St., New York, N. Y.



Two typical ovens baking armatures and coils

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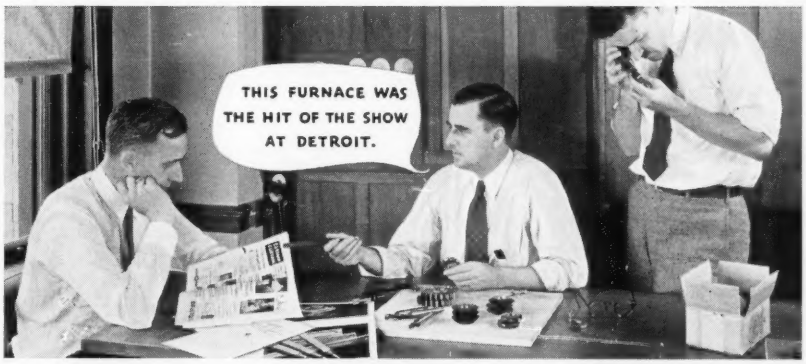
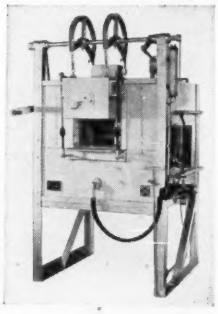


Metal Show visitors who came expressly to study the latest developments in atmosphere control, were outspoken in their opinion that "Certain Curtain" is more than ever the simplest and most practical—in fact, the only successful system for general use.

They brought hundreds of samples to be hardened at our booth, and as a result of this work we have already received several orders, as well as a host of requests to quote.

We respectfully suggest that, whatever your controlled atmosphere heat treating needs, you investigate "Certain Curtain" furnaces. Recent improvements in "Certain Curtain" control, without change of basic principles, have greatly widened the scope of application.



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Special bearing Dies
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Largest Stocks in U.S.A.
Quickest Deliveries
Safest Guarantees
Best Selections
Lowest
Costs

The Fabrication of Bi-Metallic Wire

(*Continued rom Page 727*)

IF in either the copper sheath or the steel core there exists a non-uniformity as to the hardness of the two metals then we would expect a segregation to occur in the direction of draw. This is assigned as a contributing factor in deciding the probable source of the irregular nature of the copper-steel junction previously referred to. As has been pointed out, these irregularities were found to be an individual characteristic peculiar to a particular piece of wire and also peculiar to a particular section along the axis of a piece of wire.

✦ ✦ ✦

CONSIDERING the results of the copper steel junction control studies made, with the observations made involving the wire from the scene of the explosion and the wire from the workshop of Robertson and McDonald, the similarities become strikingly significant when, in addition to the copper-steel junction similarities (Fig. 12), it was found that the die marks on the outer copper circumference or sheath (Fig. 7-A; 8-A, B, C and D) "matched" or simultaneously corresponded.

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A special Grade of Tungsten Carbide, (covered by U. S. Patents) with the proper characteristics for Dies—free from porosity—offers great resistance to abrasion and takes a polish equal to diamonds. These and other important characteristics make this metal ideal for sizing, extrusion and wire drawing Dies.
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N-O-T-I-C-E
To all readers, members and subscribers, the date of the Annual Wire Association Convention for 1939 has been changed from October 16th to that of October 23rd to 27th inclusive. Please note this change in making your plans to attend.

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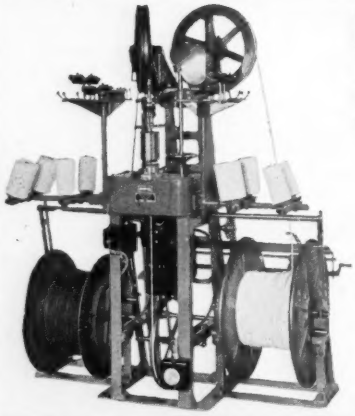
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Mid-west representative — Albert R. Breen
80 East Jackson Blvd., Chicago, Ill.

Wire Association Questions and Answers

(Continued from Page 733)

ed into the rods in successive passes. These impurities result in breakage when in contact with the drawing dies in subsequent drawing operations. Upon examination, bits of iron or steel should show at break.

3. Third cause, but also less probable, is that due to a split condition of the rods. This is due to poor rolling practice. If ingots are not shaped properly or ends of rods are not cropped after passes, split rolling may occur. This also causes breakage during subsequent drawing process."

✦ ✦ ✦

Question 4229

Effects of Alloying Elements on Hot-dip Galvanizing Properties of Steel Wire

To The Wire Association:

"I would appreciate very much any information you could obtain about the effect of various alloying elements on the hot-dip galvanizing properties of Steel Wire. In other words I am particularly interested in determining the best analysis of wire to be used for hot-dip galvanizing.

Would it be possible for me to get this information from some of the members or readers?"

✦ ✦ ✦

Answer No. 1

"YOUR query regarding the best analysis of wire to be used for hot-dipped galvanized would require a small volume to answer thoroughly. Preferably, however, the best alloying elements for this purpose are silicon and phosphorus or both. The user would have to work out his own practice based on this information."

✦ ✦ ✦

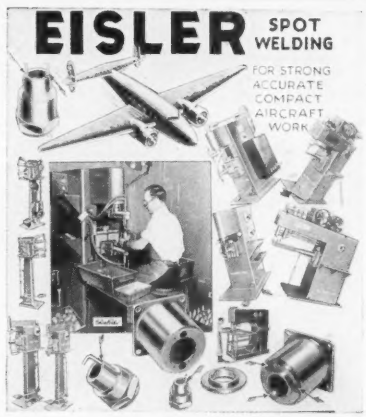
Answer No. 2

"IN answer to your inquiry I would say that we have not had sufficient experience in galvanizing wire containing sufficient alloying elements to enable us to give you very full information.

Our experience has been, mainly, with so-called plain carbon steels ranging in carbon from soft steel to the higher carbons generally used in strand and rope wire. At times these plain carbon steels might carry small percentages of other elements such as copper, with incidental contents of nickel or chromium, but these small amounts, so far as we can determine, do not make any essential difference.

In general, I doubt if one can say that there is any one special analysis of wire most adaptable to hot galvanizing. A mill that has been used to only galvanizing one type of steel would, naturally, have its practice so established that that type of steel would respond best to their particular method of operation. In other words, it has been our experience that once an organization becomes accustomed to handling a given type of steel, there is not any unusual difficulty experienced; the main thing is to get the organization trained in the handling of the work and it is difficult, if not impossible, to give explicit instructions that would mean a great deal."

(Please turn to Page 748)



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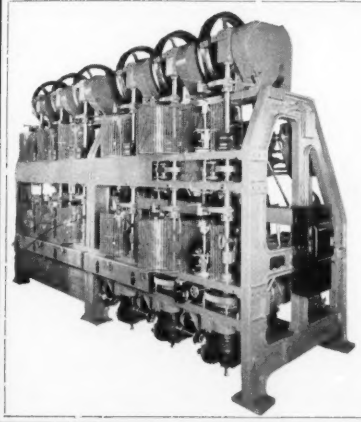

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Wire Association Questions and Answers

(Continued from Page 747)

Question 4230

Determination of Increase in Width When Rolling Round Into Flat Wire

To The Wire Association:

"We wonder if you can advise us of a formula which can be used to determine the increase in width of wire, when the wire is cold rolled into flat wire.

The metals concerned are phosphor bronzes, nickel silvers and brasses. Any information which you can give us will be appreciated".

✦ ✦ ✦

Answer No. 1

"IT is practically impossible to establish a fixed ratio due to the following reasons:

The amount of spread is predicated on the number and amount of each pass of reduction, speed of mills, the alloy being rolled and the physical properties that the wire must have, also the kind of edge required.

As we manufacture nothing but phosphor bronze—we have no data on the other alloys."

✦ ✦ ✦

Answer No. 2

"WE know of no formula which will cover all conditions and the manufacture of all sizes of Flat Wire in the alloys mentioned."

✦ ✦ ✦

Answer No. 3

"WE have been endeavoring to obtain some information concerning the size of round wire to be used in determining any particular size of flat wire. The rerolling concerns we have contacted inform us that each case will have to be determined separately, since the temper of the wire and the amount of cold rolled reduction that is made has a distinct bearing on the resulting cross section.

I am sorry that we have no specific information to pass along to the members of the Wire Association interested in this question."

✦ ✦ ✦

Answer No. 4

"WE would be very happy to know of such a formula ourselves, but we do not. It is, of course, true that long experience enables us to guess fairly close to the proper starting point in any proposition, but it is also true that any new proposition has to be worked out on its own merits depending on equipment and operating conditions of which there are several which vitally affect the result, but not in a way that can be set down in a formula so far as we have been able to discover.

A great deal of work has been done in the hope of developing a formula such as requested, but so far as we know there is nothing that can be applied to varying conditions with a surety of success."

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Wanted: Wire Spring making machinery.

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FOR SALE

BELLIS Salt Annealing equipment for annealing rods and wire.

THE SENECA WIRE & MFG. CO.
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American Steel & Wire Co. Announces Personnel Changes

E. J. REARDON, previously superintendent of the New Haven, Conn., plant of the American Steel & Wire Co., has been made general superintendent of that plant and the Trenton, N. J., Works, after the transfer of R. C. Helm, previously superintendent at Trenton, to Cleveland. Mr. Reardon is located at New Haven.

✦ ✦ ✦

S. B. METCALF, formerly general foreman of the rope department at New Haven, was made superintendent of Trenton Works and R. Murray, previously general foreman of the wire department at New Haven, became assistant superintendent at New Haven. E. E. Caspell succeeded Mr. Metcalf as general foreman of the rope department at New Haven.

✦ ✦ ✦

R. C. HELM, formerly superintendent of the Trenton, N. J., Works of the American Steel & Wire Co., has been transferred to Cleveland as superintendent of the Consolidated Works, succeeding Fred Gage, retired.

✦ ✦ ✦

JACOB J. PHIFER has been appointed superintendent of the Fairfield Wire Works of the Tennessee company, succeeding John W. Berscheid, retired. Mr. Phifer was formerly assistant superintendent.

✦ ✦ ✦

JOHN W. BERSCHEID, superintendent of the Fairfield Wire Works of the Tennessee Coal, Iron & Railroad Co. since June, 1931, was retired in July. Mr. Berscheid had been with United States Steel subsidiaries for 48 years.

✦ ✦ ✦

FRED GAGE, superintendent of the Consolidated Works of the American Steel & Wire Co., Cleveland, has retired after 46 years of service with the wire company and its predecessor, the Washburn & Moen Mfg. Co.

✦ ✦ ✦

THOMAS H. TAYLOR, former eastern sales manager for American Steel & Wire Co., Cleveland, died May 21 at his home in Higganum, Conn. He had been associated with the company from 1899 until his retirement in 1922.

✦ ✦ ✦

FRANK J. CARR, heretofore Assistant to President of American Steel & Wire Co., subsidiary of United States Steel Corpn., has been appointed Comptroller of the company.

✦ ✦ ✦

MR. CARR has been with American Steel & Wire since last March. In the four preceding years he was comptroller of the Tennessee Valley Authority at Knoxville, Tenn., and previous to that was comptroller of Aviation Corpn. and subsidiaries after having held a similar position with Hahn Department Stores.

✦ ✦ ✦

A NATIVE of Batavia, Ill., where he was born in 1892, Mr. Carr attended public schools there and in nearby Aurora, Ill., before going to the Wharton School of Finance at the University of Pennsylvania. He was graduated in 1915 with a degree of B. S. in Economics. During the World War he was a Lieutenant in the Ordnance Department of the U. S. Army.

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N-O-T-I-C-E
To all readers, members and subscribers, the date of the Annual Wire Association Convention for 1939 has been changed from October 16th to that of October 23rd to 27th inclusive. Please note this change in making your plans to attend.

Fundamental Principles of Steel Wire Metallurgy

(*Continued from Page 721*)

IN the author's opinion both factors have an influence, the fine particles tend to produce small grain and the presence of a low energy iron-aluminum combination makes high temperature necessary before rigidity can be overcome. This is a highly controversial subject, and a suitable explanation has not been provided.

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WHERE TO BUY

For more complete information, consult the annual Directory, Index & Buyers' Guide.

ABRASIVES—
Norton Co., Worcester, Mass.

ANNEALING POTS AND BOXES—
Scudder, E. J., Fdry. & Machine Co., Trenton, N. J.

ANODES—
Seymour Mfg. Co., Seymour, Conn.

ANTI-RUST—
Magnus Chemical Co., Garwood, N. J.

ARMORING EQUIPMENT—
American Insulating Mach'y. Co., Phila., Pa.
New England Butt Co., Providence, R. I.
Sleeper & Hartley, Worcester, Mass.
Syncro Machine Co., Rahway, N. J.
Watson Machine Co., Paterson, N. J.

BAKERS—Rod and Wire
The American Machine & Foundry Co., Crawford Oven Div., New Haven, Conn.
Morgan Construction Co., Worcester, Mass.

BORON CARBIDE—
Norton Co., Worcester, Mass.

CEMENT FLOOR CLEANER—
Magnus Chemical Co., Garwood, N. J.

CEMENTS—Refractory
Norton Co., Worcester, Mass.

CHEMICALS—Cleaning
American Chemical Paint Co., Ambler, Pa.
Magnus Chemical Co., Garwood, N. J.

CLEANERS—Hand and Metal
Magnus Chemical Co., Garwood, N. J.

CLEANING & PICKLING EQUIPMENT—
Broden Construction Co., Cleveland, O.
Duriron Co., The, Dayton, O.
Haveg Corp., Newark, Del.
Morgan Construction Co., Worcester, Mass.
Vaughn Machinery Co., Cuyahoga Falls, O.

COATING—Protective
American Lanolin Corp., Lawrence, Mass.

COILERS—Sheet, Strip and Wire
Broden Construction Co., Cleveland, O.
Farrel-Birmingham Co., Ansonia, Conn.
H. J. Ruesch Machine Co., Newark, N. J.
Torrington Mfg. Co., The, Torrington, Conn.

CONDUITS—Iron and Steel
Youngstown Sheet & Tube Co., Youngstown, Ohio.

CONTROLS—Automatic
Leeds & Northrup Co., Philadelphia, Pa.

CRANES—Wire Mill
Cleveland Tramrail div. of Cleveland Crane and Engineering Co., Wickliffe, O.
Morgan Construction Co., Worcester, Mass.
Vaughn Machinery Co., Cuyahoga Falls, O.

DIAMOND TOOLS—
Rusch Wire Die Corp., New York, N. Y.

DIES—Diamond
Balloffet Die & Nozzle Co., Inc., Guttenberg, N. J.
Cochaud Wire Die Co., New York, N. Y.
Kelly Wire Die Corp., New York, N. Y.
Rusch Wire Die Corp., New York, N. Y.
Vianney Wire Die Works, New York, N. Y.
Willey's Carbide Tool Co., Detroit, Mich.

DIES—Lead Extrusion
John Robertson Co., Brooklyn, N. Y.

DIES—Repairs & Re-Cutting
Balloffet Die & Nozzle Co., Inc., Guttenberg, N. J.
Carboloy Co., Inc., Detroit, Mich.
Cochaud Wire Die Co., New York, N. Y.
Firth-Sterling Steel Co., McKeesport, Pa.
Kelly Wire Die Corp., New York, N. Y.
Rusch Wire Die Corp., New York, N. Y.
Vianney Wire Die Works, New York, N. Y.
Willeys Carbide Tool Co., Detroit, Mich.

DIES—Rod and Tube Drawing
Carboloy Co., Inc., Detroit, Mich.
Firth-Sterling Steel Co., McKeesport, Pa.
Kelly Wire Die Corp., New York, N. Y.
Rusch Wire Die Corp., New York, N. Y.
Vianney Wire Die Works, New York, N. Y.
Willeys Carbide Tool Co., Detroit, Mich.

DIES—Tantalum Carbide
Balloffet Die & Nozzle Co., Inc., Guttenberg, N. J.
Carboloy Co., Inc., Detroit, Mich.
Kelly Wire Die Corp., New York, N. Y.
Rusch Wire Die Corp., New York, N. Y.
Vianney Wire Die Works, New York, N. Y.

DIES—Tungsten Carbide
Balloffet Die & Nozzle Co., Inc., Guttenberg, N. J.
Carboloy Co., Inc., Detroit, Mich.
Firth-Sterling Steel Co., McKeesport, Pa.
Kelly Wire Die Corp., New York, N. Y.

WHERE TO BUY, Continued

Rusch Wire Die Corp., New York, N. Y.
Vianney Wire Die Works, New York, N. Y.
Willey's Carbide Tool Co., Detroit, Mich.

DRAW BENCHES—
H. J. Ruesch Machine Co., Newark, N. J.
Scudder, E. J., Fdry. & Machine Co., Trenton, N. J.
Vaughn Machinery Co., Cuyahoga Falls, O

DRUMS—Flange Steel
Stevens Metal Products Co., Niles, O.

ENGINEERS—Consulting Wire Mill
Lewis, Kenneth B., New York, N. Y.
Hartley, George D., Worcester, Mass.

EQUIPMENT—Insulation Testing
Leeds & Northrup Co., Philadelphia, Pa.

EYELETS—Brass or Zinc
Platt Bros. & Co., The, Waterbury, Conn.

FILLERS—Paper for Cable
E. W. Twitchell, Inc., Phila., Pa.

FURNACE CONTROLS — Combustion and Draft
Leeds & Northrup Co., Philadelphia, Pa.

FURNACES—Annealing
Electric Furnace Co., Salem, O.
Leeds & Northrup Co., Philadelphia, Pa.

FURNACES—Automatic
Electric Furnace Co., Salem, O.
Leeds & Northrup Co., Philadelphia, Pa.

FURNACES—Bright Annealing
Electric Furnace Co., Salem, O.
Hayes, C. I., Inc., Providence, R. I.

FURNACES—Electric
Electric Furnace Co., Salem, O.
Hayes, C. I., Inc., Providence, R. I.

FURNACES—Hardening and Tempering
Electric Furnace Co., Salem, O.
Hayes, C. I., Inc., Providence, R. I.
Leeds & Northrup Co., Philadelphia, Pa.

FURNACES—Lead Melting
Electric Furnace Co., Salem, O.
John Robertson Co., Brooklyn, N. Y.

FURNACES—Non-Oxidizing
Electric Furnace Co., Salem, O.

FURNACES—Normalizing
Electric Furnace Co., Salem, O.
Leeds & Northrup Co., Philadelphia, Pa.

FURNACES—Wire, Strip & Sheet
Electric Furnace Co., Salem, O.

GEARS—Wire Mill
Farrel-Birmingham Co., Ansonia, Conn.

GRINDERS—ROLL
Farrel-Birmingham Co., Ansonia, Conn.
Norton Co., Worcester, Mass.

HOISTS—Electric Travelling
Cleveland Tramrail div. of Cleveland Crane and Engineering Co., Wickliffe, O.

INHIBITORS—
American Chemical Paint Co., Ambler, Pa.

INSTRUMENTS—Electrical
Leeds & Northrup Co., Philadelphia, Pa.

INSULATION — Cable or Cable Filler
E. W. Twitchell, Inc., Phila., Pa.

LATHES—Die Reaming
Morgan Construction Co., Worcester, Mass.
Vaughn Machinery Co., Cuyahoga Falls, O.

LUBRICANTS—For Metal Cutting, Stamping and Drawing
Magnus Chemical Co., Garwood, N. J.

LUBRICANTS—Wire Drawing
Magnus Chemical Co., Garwood, N. J.

MACHINERY—Armoring (Cable, Wire Hose)
American Insulating Mach'y. Co., Phila., Pa.
New England Butt Co., Providence, R. I.
John Robertson Co., Brooklyn, N. Y.
Sleeper & Hartley, Inc., Worcester, Mass.
Syncro Machine Co., Rahway, N. J.
Thomson-Judd Wire Machinery Co., Lynn, Mass.
Torrington Mfg. Co., The, Torrington, Conn.
Watson Machine Co., Paterson, N. J.

MACHINERY—Braiding
Fidelity Machine Co., Philadelphia, Pa.
New England Butt Co., Providence, R. I.
Watson Machine Co., Paterson, N. J.

MACHINERY—Brazing
Hayes, C. I., Inc., Providence, R. I.
Thomson-Judd Wire Machinery Co., Lynn, Mass.

MACHINERY—Bunching
American Insulating Mach'y. Co., Phila., Pa.
New England Butt Co., Providence, R. I.
Sleeper & Hartley, Inc., Worcester, Mass.
Syncro Machine Co., Rahway, N. J.
Watson Machine Co., Paterson, N. J.

MACHINERY—Bundling, Scrap
Sleeper & Hartley, Inc., Worcester, Mass.
Vaughn Machinery Co., Cuyahoga Falls, O.
Watson Machine Co., Paterson, N. J.

MACHINERY—Cable, Electric
American Insulating Mach'y. Co., Phila., Pa.
Fidelity Machine Co., Philadelphia, Pa.
New England Butt Co., Providence, R. I.
Syncro Machine Co., Rahway, N. J.
Thomson-Gibb Electric Welding Co., Lynn, Mass.
Torrington Mfg. Co., The, Torrington, Conn.
Watson Machine Co., Paterson, N. J.

MACHINERY—Chain Making
Vaughn Machinery Co., Cuyahoga Falls, O.

MACHINERY—Closing
New England Butt Co., Providence, R. I.
Torrington Mfg. Co., The, Torrington, Conn.
Watson Machine Co., Paterson, N. J.

MACHINERY—Coil Winding
Sleeper & Hartley, Inc., Worcester, Mass.
Torrington Mfg. Co., The, Torrington, Conn.

MACHINERY—Coilers
Broden Construction Co., Cleveland, O.
Farrel-Birmingham Co., Ansonia, Conn.
Morgan Construction Co., Worcester, Mass.
New England Butt Co., Providence, R. I.
H. J. Ruesch Machine Co., Newark, N. J.
Sleeper & Hartley, Inc., Worcester, Mass.
Syncro Machine Co., Rahway, N. J.
Torrington Mfg. Co., The, Torrington, Conn.
Waterbury-Farrel Fdry. & Machine Co., Waterbury, Conn.
Watson Machine Co., Paterson, N. J.

MACHINERY—Copper Wire Drawing and Rolling
Farrel-Birmingham Co., Ansonia, Conn.
H. J. Ruesch Machine Co., Newark, N. J.
Syncro Machine Co., Rahway, N. J.
Torrington Mfg. Co., The, Torrington, Conn.
Vaughn Machinery Co., Cuyahoga Falls, O.
Waterbury-Farrel Fdry. & Machine Co., Waterbury, Conn.

MACHINERY—Covering Wire
Sinfra Corp., Jersey City, N. J.
Syncro Machine Co., Rahway, N. J.

MACHINERY—Cutting
Broden Construction Co., Cleveland, O.
Farrel-Birmingham Co., Ansonia, Conn.
Hallden Machine Co., Thomaston, Conn.
Lewis Machine Co., The, Cleveland, O.
National Machinery Exchange, New York, N. Y.
F. B. Shuster Co., New Haven, Conn.
W. A. Schuyler, New York, N. Y.
Sleeper & Hartley, Inc., Worcester, Mass.

MACHINERY—Enameling
American Insulating Mach'y. Co., Phila., Pa.
Syncro Machine Co., Rahway, N. J.

MACHINERY—Extruding
John Robertson Co., Brooklyn, N. Y.
Royle, John & Sons, Paterson, N. J.
Watson Machine Co., Paterson, N. J.

MACHINERY—Flat Wire
Broden Construction Co., Cleveland, O.
H. J. Ruesch Machine Co., Newark, N. J.
Sleeper & Hartley, Inc., Worcester, Mass.
Torrington Mfg. Co., The, Torrington, Conn.

MACHINERY—Forming
National Machinery Exchange, New York, N. Y.
Sleeper & Hartley, Inc., Worcester, Mass.
Torrington Mfg. Co., The, Torrington, Conn.

MACHINERY—Galvanizing Wire
Broden Construction Co., Cleveland, O.
Sleeper & Hartley, Inc., Worcester, Mass.
Vaughn Machinery Co., Cuyahoga Falls, O.

MACHINERY—Gang Winders
Fidelity Machine Co., Philadelphia, Pa.
H. J. Ruesch Machine Co., Newark, N. J.
Watson Machine Co., Paterson, N. J.

MACHINERY—Grinding
Norton Co., Worcester, Mass.

MACHINERY—Insulating
American Insulating Mach'y. Co., Phila., Pa.
Fidelity Machine Co., Philadelphia, Pa.
New England Butt Co., Providence, R. I.
Sinfra Corporation, Jersey City, N. J.
Syncro Machine Co., Rahway, N. J.
Watson Machine Co., Paterson, N. J.

MACHINERY—Knitting
Sinfra Corporation, Jersey City, N. J.

MACHINERY—Lead Encasing Presses, etc.
John Robertson Co., Brooklyn, N. Y.

MACHINERY—Lead Stripping
John Robertson Co., Brooklyn, N. Y.
Watson Machine Co., Paterson, N. J.

MACHINERY—Lock Washer
Sleeper & Hartley, Inc., Worcester, Mass.
Torrington Mfg. Co., Torrington, Conn.

MACHINERY—Magnet Wire
American Insulating Mach'y. Co., Phila., Pa.
New England Butt Co., Providence, R. I.
Sleeper & Hartley, Inc., Worcester, Mass.
Syncro Machine Co., Rahway, N. J.
Torrington Mfg. Co., The, Torrington, Conn.

MACHINERY—Material Handling
Cleveland Tramrail div. of Cleveland Crane and Engineering Co., Wickliffe, O.

MACHINERY — Measuring Wire & Cable
New England Butt Co., Providence, R. I.
Watson Machine Co., Paterson, N. J.

MACHINERY—Nail and Tack
Glader, Wm., Machine Works Co., Chicago, Ill.
Sleeper & Hartley, Inc., Worcester, Mass.

MACHINERY—Panning
American Insulating Mach'y. Co., Phila., Pa.
Syncro Machine Co., Rahway, N. J.

MACHINERY—Pointing
Broden Construction Co., Cleveland, O.
H. J. Ruesch Machine Co., Newark, N. J.
Scudder, E. J., Fdry. & Machine Co., Trenton, N. J.
Sleeper & Hartley, Inc., Worcester, Mass.
Syncro Machine Co., Rahway, N. J.
Torrington Mfg. Co., The, Torrington, Conn.
Vaughn Machinery Co., Cuyahoga Falls, O.
Waterbury-Farrel Fdry. & Machine Co., Waterbury, Conn.

MACHINERY—Rod Mill
Broden Construction Co., Cleveland, O.
Farrel-Birmingham Co., Ansonia, Conn.
Morgan Construction Co., Worcester, Mass.
H. J. Ruesch Machine Co., Newark, N. J.
W. A. Schuyler, New York, N. Y.

MACHINERY—Rolling Mill
Broden Construction Co., Cleveland, O.
Farrel-Birmingham Co., Ansonia, Conn.
Morgan Construction Co., Worcester, Mass.
H. J. Ruesch Machine Co., Newark, N. J.
Syncro Machine Co., Rahway, N. J.
Torrington Mfg. Co., The, Torrington, Conn.
Waterbury-Farrel Fdry. & Machine Co., Waterbury, Conn.

MACHINERY—Rubber Strip Covering
Farrel-Birmingham Co., Ansonia, Conn.
New England Butt Co., Providence, R. I.
Watson Machine Co., Paterson, N. J.

MACHINERY—Rubber Tubing and Straining
Farrel-Birmingham Co., Ansonia, Conn.
New England Butt Co., Providence, R. I.
Royle, John, & Sons., Paterson, N. J.
Sleeper & Hartley, Inc., Worcester, Mass.
Torrington Mfg. Co., The, Torrington, Conn.
Watson Machine Co., Paterson, N. J.

MACHINERY—Screw Wire
Sleeper & Hartley, Worcester, Mass.

MACHINERY—Special
American Insulating Mach'y. Co., Phila., Pa.
Broden Construction Co., Cleveland, O.
New England Butt Co., Providence, R. I.
H. J. Ruesch Machine Co., Newark, N. J.
Scudder, E. J., Fdry. & Machine Co., Trenton, N. J.
Sleeper & Hartley, Inc., Worcester, Mass.
Syncro Machine Co., Rahway, N. J.
Torrington Mfg. Co., The, Torrington, Conn.
Watson Machine Co., Paterson, N. J.

MACHINERY— Special — Combination Machine for Drawing, Cutting-to-length. Straightening and Reeling Bars from Coil in One Operation (Shumag Type)—
W. A. Schuyler, New York, N. Y.

WHERE TO BUY, Continued

MACHINERY—Spooling
American Insulating Mach'y. Co., Phila., Pa.
Fidelity Machine Co., Philadelphia, Pa.
New England Butt Co., Providence, R. I.
Sleeper & Hartley, Inc., Worcester, Mass.
Syncro Machine Co., Rahway, N. J.
Torrington Mfg. Co., The, Torrington, Conn.
Vaughn Machinery Co., Cuyahoga Falls, O.
Waterbury-Farrel Fdry. & Machine Co., Waterbury, Conn.
Watson Machine Co., Paterson, N. J.

MACHINERY—Spring Making
Sleeper & Hartley, Inc., Worcester, Mass.
Torrington Mfg. Co., The, Torrington, Conn.

MACHINERY—Staple
Sleeper & Hartley, Inc., Worcester, Mass.

MACHINERY—Straightening
Broden Construction Co., Cleveland, O.
Hallden Machine Co., Thomaston, Conn.
Lewis Machine Co., The, Cleveland, O.
National Machinery Exchange, New York, N. Y.
H. J. Ruesch Machine Co., Newark, N. J.
W. A. Schuyler, New York, N. Y.
F. B. Shuster, New Haven, Conn.
Sleeper & Hartley, Inc., Worcester, Mass.
Torrington Mfg. Co., The, Torrington, Conn.

MACHINERY—Stranding
New England Butt Co., Providence, R. I.
Sleeper & Hartley, Inc., Worcester, Mass.
Thomson-Judd Wire Machinery Co., Lynn, Mass.
Torrington Mfg. Co., The, Torrington, Conn.
Watson Machine Co., Paterson, N. J.

MACHINERY—Strip Steel
Broden Construction Co., Cleveland, O.
H. J. Ruesch Machine Co., Newark, N. J.
Torrington Mfg. Co., The, Torrington, Conn.

MACHINERY—Swaging
National Machinery Exchange, New York, N. Y.
H. J. Ruesch Machine Co., Newark, N. J.
Sleeper & Hartley, Inc., Worcester, Mass.
Syncro Machine Co., Rahway, N. J.
Torrington Mfg. Co., The, Torrington, Conn.
Waterbury-Farrel Fdry. & Machine Co., Waterbury, Conn.

MACHINERY—Taping
American Insulating Mach'y. Co., Phila., Pa.
Fidelity Machine Co., Philadelphia, Pa.
New England Butt Co., Providence, R. I.
Syncro Machine Co., Rahway, N. J.
Thomson-Judd Wire Machinery Co., Lynn, Mass.
Torrington Mfg. Co., The, Torrington, Conn.
Watson Machine Co., Paterson, N. J.

MACHINERY—Testing Size of Wire
Torrington Mfg. Co., The, Torrington, Conn.

MACHINERY—Tinsel Rolling Mills
American Insulating Mach'y. Co., Phila., Pa.
Syncro Machine Co., Rahway, N. J.

MACHINERY—Trolley Wire
Vaughn Machinery Co., Cuyahoga Falls, O.

MACHINERY—Tube Mill
H. J. Ruesch Machine Co., Newark, N. J.
Torrington Mfg. Co., The, Torrington, Conn.

MACHINERY—Welding Wire
Eisler Engineering Co., Inc., Newark, N. J.
Micro Products Co., Chicago, Ill.
F. B. Shuster Co., New Haven, Conn.
Thomson-Judd Wire Machinery Co., Lynn, Mass.

MACHINERY—Winding
American Insulating Mach'y. Co., Phila., Pa.
Fidelity Machine Co., Philadelphia, Pa.
New England Butt Co., Providence, R. I.
Sleeper & Hartley, Inc., Worcester, Mass.
Syncro Machine Co., Rahway, N. J.
Torrington Mfg. Co., The, Torrington, Conn.
Watson Machine Co., Paterson, N. J.

MACHINERY—Wire Drawing
Aetna-Standard Engineering Co., Youngstown, O.
American Insulating Mach'y. Co., Phila., Pa.
Broden Construction Co., Cleveland, O.
Morgan Construction Co., Worcester, Mass.
National Machinery Exchange, New, York, N. Y.
H. J. Ruesch Machine Co., Newark, N. J.
Scudder, E. J., Fdry. & Machine Co., Trenton, N. J.
W. A. Schuyler, New York, N. Y.
Sleeper & Hartley, Inc., Worcester, Mass.
Syncro Machine Co., Rahway, N. J.
Thomson-Judd Wire Machinery Co., Lynn, Mass.
Torrington Mfg. Co., The, Torrington, Conn.
Vaughn Machinery Co., Cuyahoga Falls, O.

MACHINERY—Wire Rope
New England Butt Co., Providence, R. I.
Thomson-Judd Wire Machinery Co., Lynn, Mass.
Watson Machine Co., Paterson, N. J.

MACHINERY—Wire Tinning
American Insulating Mach'y. Co., Phila., Pa.
New England Butt Co., Providence, R. I.
Syncro Machine Co., Rahway, N. J.

MACHINERY—Wrapping Wire
W. A. Schuyler, New York, N. Y.

MILLS—Tandem Rolling and Edging
Torrington Mfg. Co., The, Torrington, Conn.

NICKEL SILVER AND PHOSPHOR BRONZE—Rod, Wire and Strip
Hudson Wire Co., Ossining, N. Y.
Seymour Mfg. Co., Seymour, Conn.

OVENS—Brazing
The American Machine & Foundry Co., Crawford Oven Div., New Haven, Conn.
Hayes, C. I., Inc., Providence, R. I.

Ovens for All Purposes in the Wire Industry
The American Machine & Foundry Co., Crawford Oven Div., New Haven, Conn.
Hayes, C. I., Inc., Providence, R. I.

PAPER—Insulating
E. W. Twitchell, Inc., Phila., Pa.

PATENT ATTORNEYS—
Lancaster, Allwine and Rommel, Washington, D. C.

PICKLING COMPOUNDS
American Chemical Paint Co., Ambler, Pa.

PIPING AND FITTINGS—Acid Resistant
Duriron Co., Inc., The, Dayton, O.
Haveg Corp., Newark, Del.

POTS—Lead Melting
Farrel-Birmingham Co., Ansonia, Conn.
John Robertson Co., Brooklyn, N. Y.

PRESSES—Hydraulic and Mechanical
Farrel-Birmingham Co., Ansonia, Conn.
John Robertson Co., Brooklyn, N. Y.

PRESSES—Lead
John Robertson Co., Brooklyn, N. Y.

PULLERS—Wire
Scudder, E. J., Fdry. & Machine Co., Trenton, N. J.
Sleeper & Hartley, Inc., Worcester, Mass.

PUMPS—Hydraulic
John Robertson Co., Brooklyn, N. Y.

PYROMETERS—
Leeds & Northrup Co., Philadelphia, Pa.

RECORDERS—
Leeds & Northrup Co., Philadelphia, Pa.

REEL AND TENSION STAND—
Fidelity Machine Co., Philadelphia, Pa.
Sleeper & Hartley, Inc., Worcester, Mass.
Torrington Mfg. Co., The, Torrington, Conn.

REEL CRUTCHES—
Watson Machine Co., Paterson, N. J.

REELS—Annealing and Stranding
Stevens Metal Products Co., Niles, O.

REELS—Steel
Stevens Metal Products Co., Niles, O.

REELS AND SPOOLS—Shipping and Shop
Stevens Metal Products Co., Niles, O.

REFRACTORIES—High Temperature
Norton Co., Worcester, Mass.

ROD BAKERS—
The American Machine & Foundry Co., Crawford Oven Div., New Haven, Conn.

RODS—Wire—Non-Ferrous
Hudson Wire Co., Ossining, N. Y.
Platt Bros. & Co., The, Waterbury, Conn.
Seymour Mfg. Co., Seymour, Conn.

RODS—Wire—Steel
Continental Steel Corp., Kokomo, Ind.
Keystone Steel & Wire Co., Peoria, Ill.
Pittsburgh Steel Co., Pittsburgh, Pa.
Republic Steel Corp., Cleveland, O.
Youngstown Sheet & Tube Co., Youngstown, Ohio.

ROLLS—
Farrel-Birmingham Co., Ansonia, Conn.

RUST PROOF COMPOUND—
American Lanolin Co., Lawrence, Mass.

SHEET—Steel
Continental Steel Corp., Kokomo, Ind.
Republic Steel Corp., Cleveland, O.
Youngstown Sheet & Tube Co., Youngstown, Ohio.

SKIN PROTECTOR—
Magnus Chemical Co., Garwood, N. J.

SOAPS—Industrial and Wire Drawing
Magnus Chemical Co., Garwood, N. J.

SPOOLS—Steel
Stevens Metal Products Co., Niles, O.

STRIP—Brass and Non Ferrous
Hudson Wire Co., Ossining, N. Y.
Seymour Mfg. Co., Seymour, Conn.

STRIP—Steel
Continental Steel Corp., Kokomo, Ind.
Firth-Sterling Steel Co., McKeesport, Pa.
Pittsburgh Steel Co., Pittsburgh, Pa.
Republic Steel Corp., Cleveland, O.

TANKS—Compound
Watson Machine Co., Paterson, N. J.

TANKS—Pickling
Haveg Corp., Newark, Del.

TRAMRAIL SYSTEMS—
Cleveland Tramrail div. of Cleveland Crane and Engineering Co., Wickliffe, O.

TREADS—Safety
Norton Co., Worcester, Mass.

TRUCKS—
Morgan Construction Co., Worcester, Mass.
Vaughn Machinery Co., Cuyahoga Falls, O.

TUBE BENDERS AND FORMERS—
H. J. Ruesch Machine Co., Newark, N. J.

VALVES AND FITTINGS—Acid Proof
Duriron Co., The, Dayton, O.
Haveg Corp., Newark, Del.

VULCANIZERS—
Watson Machine Co., Paterson, N. J.

VULCANIZING PANS—
American Insulating Mach'y. Co., Phila., Pa.

WELDERS—Spot and Butt
Eisler Engineering Co., Newark, N. J.
Micro Products Co., Chicago, Ill.

WIRE—Cold Heading
Continental Steel Corp., Kokomo, Ind.
Keystone Steel & Wire Co., Peoria, Ill.
Pittsburgh Steel Co., Pittsburgh, Pa.
Republic Steel Corp., Cleveland, O.
Youngstown Sheet & Tube Co., Youngstown, Ohio.

WIRE—Electric
Hudson Wire Co., Ossining, N. Y.
Seymour Mfg. Co., Seymour, Conn.

WIRE—Enameled For Coils
Winsted Div. of Hudson Wire Co., Winsted, Conn.

WIRE—Manufacturers
Continental Steel Corp., Kokomo, Ind.
Keystone Steel & Wire Co., Peoria, Ill.
Pittsburgh Steel Co., Pittsburgh, Pa.
Republic Steel Corp., Cleveland, O.
Youngstown Sheet & Tube Co., Youngstown, Ohio.

WIRE—Nickel Silver and Phosphor Bronze
Hudson Wire Co., Ossining, N. Y.
Seymour Mfg. Co., Seymour, Conn.

WIRE—Non Ferrous to Specification For Special Purposes
Hudson Wire Co., Ossining, N. Y.
Seymour Mfg. Co., Seymour, Conn.
Winsted Div. of Hudson Wire Co., Winsted, Conn.

WIRE—Spring
Continental Steel Corp., Kokomo, Ind.
Keystone Steel & Wire Co., Peoria, Ill.
Pittsburgh Steel Co., Pittsburgh, Pa.
Seymour Mfg. Co., Seymour, Conn.
Youngstown Sheet & Tube Co., Youngstown, Ohio.

WIRE—Steel—Also Coppered Steel——Also Galvanized Steel
Continental Steel Corp., Kokomo, Ind.
Keystone Steel & Wire Co., Peoria, Ill.
Pittsburgh Steel Co., Pittsburgh, Pa.
Republic Steel Corp., Cleveland, O.
Youngstown Sheet & Tube Co., Youngstown, Ohio.

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Platt Bros. & Co., The Waterbury, Conn.

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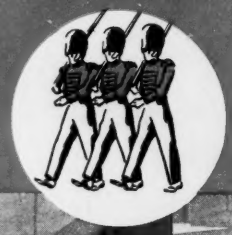

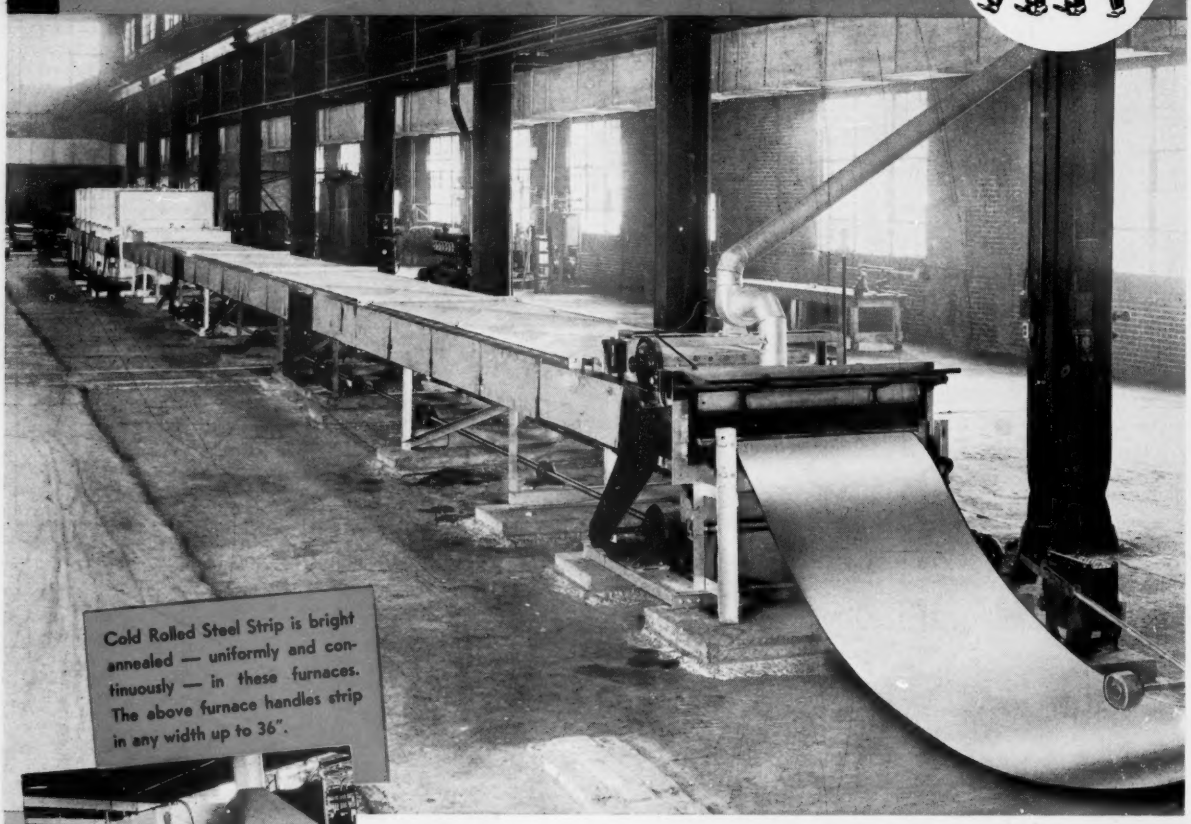

Cold Rolled Steel Strip is bright annealed — uniformly and continuously — in these furnaces. The above furnace handles strip in any width up to 36".

Another continuous furnace bright annealing 3" strips of cold rolled steel at once.

Discharge end of another continuous furnace for bright annealing both wide and narrow strip.

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